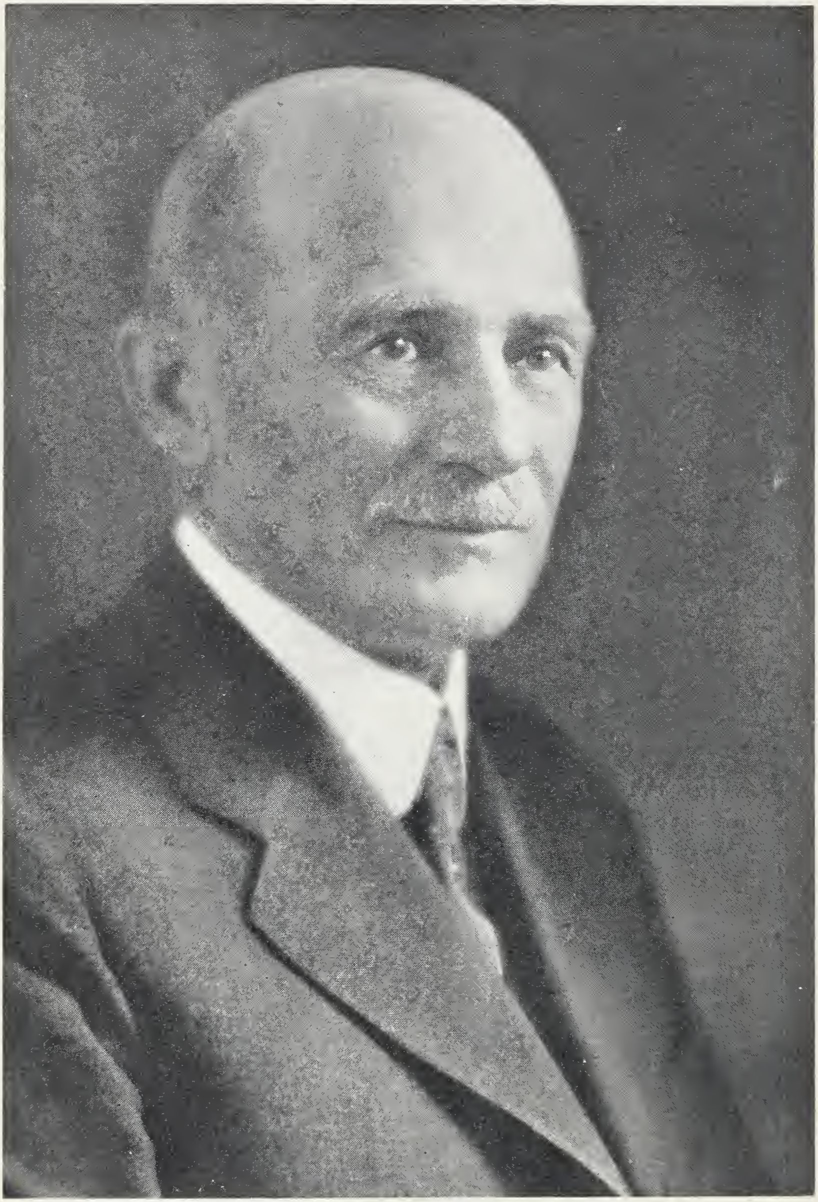
A HISTORY OF

Agricultural Experimentation and Research

IN THE UNITED STATES

1607–1925

ALFRED CHARLES TRUE



EDWIN WEST ALLEN

1864–1929

Connected with the Office of Experiment Stations of the United States Department of Agriculture from 1890 to 1929, and its Chief from 1915 until his death, November 11, 1929, Dr. Allen rendered notable service in the development of agricultural research in the United States.

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A History of Agricultural Experimentation and Research in the United States

1607-1925

Including

A History of the United States Department of Agriculture

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United States Department of Agriculture

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PREFACE

This is the third and final monograph in a series intended to give a comprehensive summary of the history of agricultural education, extension, and research in the United States. Agricultural instruction in schools and colleges, with incidental references to research and extension work as features of the broad American system of agricultural education, was dealt with in the monograph published in 1929 as Miscellaneous Publication No. 36 of the United States Department of Agriculture. The History of Agricultural Extension Work was issued by this Department in 1928 as Miscellaneous Publication No. 15.

On the same plan as was followed in the monographs on agricultural education and extension work, this publication gives typical examples of the work of private individuals and organizations in laying the foundation for the establishment of public agencies for agricultural research. It tells how agencies dealing exclusively or in large measure with agricultural research developed from organizations in which such research was a minor feature, as in the case of geological surveys, the Patent Office, and the agricultural colleges. The early work of the United States Department of Agriculture and the State experiment stations has been described in some detail because accounts of the work at this stage are not readily available elsewhere. For the same reason biographical information regarding the early workers has been included.

After the passage of the Hatch Experiment Station Act and the reorganization of the Department of Agriculture as of Cabinet rank, the work of these agencies spread out so broadly that it was not possible to give more than brief summaries of principal undertakings. These more and more represented the combined efforts of different individuals and institutions. Agricultural science grew chiefly as the result of numerous small additions to knowledge, credit for which it was increasingly difficult to give to individuals. Results of particular projects in both their scientific and practical aspects became very hard to measure. To be at all adequate, such measurement must be the task of specialists, and for the most part this has not yet been attempted. Therefore, in this general survey of the history of agricultural experimentation and research in this country, little has been attempted beyond describing the organization and equipment of such research and its general character and breadth.

The material for this history has been drawn chiefly from general reports of the work. An examination in detail of the vast mass of bulletins and special reports issued by the Department of Agriculture and the experiment stations was obviously impracticable.

W. H. Beal and H. M. Steece of the Office of Experiment Stations carefully read the manuscript and made many helpful suggestions for its improvement. Special acknowledgment is also made of the assistance of E. B. Hawks of the Department Library, C. L. Feldkamp of the library of the Office of Experiment Stations, and J. L. Weston of this Office.

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AGRICULTURAL RESEARCH IN THE UNITED STATES

BEGINNINGS IN THE AMERICAN COLONIES AND EARLY STATES

SIGNIFICANT CONTRIBUTIONS RESULTING FROM INDIVIDUAL EFFORT AND COLONIAL SUBSIDIES

The first permanent English colonists in North America, at Jamestown, Va., in 1607, and Plymouth, Mass., in 1620, profited greatly from the primitive agriculture of the native Indians, but soon set about improving it (*29, pp. 23, 119, 124, 129, 139*). They were obliged to determine by experimental plantings what crops would grow best in their respective regions and what would be most satisfactory as material for food and clothing for themselves, as feed for their livestock, and as money crops. For these purposes they tried such plants as maize, beans, pumpkins, and tobacco, which were grown by the Indians; the European cereals, fruits, and vegetables, such as apples, peaches, wheat, barley, rye, oats, turnips, and carrots; and products, found in Central America and South America by explorers and already grown in the Old World or in the West Indies, such as potatoes, sweetpotatoes, and cotton.

The desirability of encouraging agriculture through aid from the Government or from corporations promoting settlement in this country was early recognized. In 1622 James I of England encouraged the breeding of silkworms (*77, p. 5*)[1], and in 1656 it was ordered that every landowner in Virginia should plant 10 mulberry trees for every 100 acres he possessed (*29, p. 133*). The following year the Virginia Assembly voted that whoever "shall first make 100 pounds of wound silk in one yeare" should be paid 5,000 pounds of tobacco. That same year this assembly passed an act to stimulate the growing of hops. In 1642 the General Court of Massachusetts offered premiums to encourage the raising of sheep.

John Winthrop, Jr., who followed his father to the Massachusetts Colony in 1631 and became Governor of Connecticut in 1635, was a member of the Royal Society of England. At the request of the society, he made experiments in brewing beer from corn and reported the results in a paper entitled "Description, Culture and Use of Maize", which was published in the Philosophical Transactions of the society in 1678. In this paper he also called attention to the possibility of making sirup and sugar from cornstalks. In 1688 John Clayton, of Virginia, presented to this society a paper entitled "Observables of Virginia", in which he called attention to the effect of different soils on the quality of tobacco.

In 1669 the Lords Proprietors of Carolina sent an expedition under Joseph West to make a settlement on the Ashley River (*29 p. 200*). He was instructed to stop at the Barbados and obtain "cotton seed,

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[1] Italic numbers in parentheses refer to Bibliography, p. 278.

indigo seed, ginger roots * * *, some canes, ollive setts", etc., and to make experimental plantings with reference to soils best suited to each species, and times of planting, and also to provide seeds and cuttings for use on the plantation. A "man or two" were to do the experimental work, while the rest of the people were raising ordinary crops for food. After 2 years' trial it was reported that the winters in South Carolina were too cold for sugarcane and cotton (i. e., perennial cotton imported from the West Indies). "Wine, Oyle, Silk, Indicoe, Tobacco, Hemp, Flax, and some say Ginger" might be produced for export.

When the settlement of Savannah, Ga., was begun under the leadership of James Oglethorpe in 1733, the example of South Carolina was followed. Immediately an experimental garden was planted, which was described by Von Reck, a German from Saltzburg, who arrived there a few months later, as follows:

> There is laid out out near the Town by order of the Trustees a Garden for making experiments for the Improving of Botany and Agriculture. It contains ten Acres, and lies upon the River; and it is cleared and brought into such Order that there is already a fine nursery of Oranges, Olives, White Mulberries, Figs, Peaches, and many curious Herbs; besides which there is Cabbage, Peas and other European Pulse and plants, which all thrive (*29, p. 209*).

Robert Millar, a botanist, was employed for 5 years in the West Indies, Central America, and South America in collecting plants for this garden. It was supported partly by funds furnished by the trustees and partly by private contributions. After 1740 interest in this garden declined, but the project was continued, at least in part, for several years longer. It was there demonstrated that oranges and tropical plants would not survive in that climate.

Lands in Georgia were granted on the same condition regarding the planting of mulberry trees as had previously been made in Virginia. "An Episcopal clergyman and a native of piedmont were engaged to instruct the people in the art of rearing the worms and winding the silk." Between 1733 and 1743 the English Parliament granted about $600,000 to promote the growing of indigo and other crops in that colony.

William Penn, who first brought English settlers into Pennsylvania in 1681,

> was a leader in agricultural advancement. He imported well-bred horses, experimented with grass growing and encouraged his people in agricultural improvements. To his secretary, James Logan [who came to this country in 1699], must be ascribed the honor of being the first scientific agriculturist in this country. Logan's observations on the botanical nature of maize were remarkable for their accuracy. He it was who after careful experimentation first recorded how the grain of maize resulted from the union of the pollen of the tassel with the silk of the ear (*29, p. 176*).

An account of these experiments was published in 1735.

The farmers of Connecticut, who were greatly troubled by diseases of wheat, were so watchful for causes and remedies that in 1726 they secured a law for the eradication of barberry bushes, which had the following preamble:

> Whereas the abounding of barberry bushes is thought to be very hurtful, it being by plentiful experience found that, where they are in large quantities, they do occasion, or at least increase, the blast on all sorts of English grain * * * (*29 p. 185*).

In New England the growing of silkworms and the making of silk were actively promoted, beginning with 1727 when Dr. Wigglesworth, of Harvard College, began raising the worms. In 1734 the Colony of Connecticut encouraged, by bounties, the production of silk. Ezra Stiles, president of Yale College from 1777 to 1795, made a careful experiment in growing about 3,000 silkworms and "kept a full record of his daily observations." This record is preserved in the library of Yale University, in a manuscript entitled "Observations on the Silk Worm and the Culture of Silk, A. D. 1763." He afterward "sent to each of eighty ministers in the State enough mulberry seed to grow 4,000 trees."

Jared Eliot (*245*), of Killingworth, Conn., a graduate of Yale, and minister, physician, botanist, and farmer, published from 1748 to 1761 a series (with an index) of Essays upon Field-Husbandry in New-England, As it is or may be Ordered (*57*). These essays were "wrote from a Journal of thirty years' experience" and along with the discussion of many agricultural subjects included accounts of experiments in draining swamps and wet meadows, growing millet, making farm implements, etc. With the aid of President Clap, of Yale College, Eliot secured a new model of a wheat drill and caused Benoni Hylliard, a wheelwright of Killingworth, to devise a combination drill which distributed manure and seed, and for which the New London Society for the Encouragement of Arts gave an award of 50 pounds. Eliot is said to have introduced the growing of clover and chicory in Connecticut.

In 1728 John Bartram (*221*) (1699–1777) was induced by Peter Collinson, of London, to establish a botanical garden on the bank of the Schuylkill River, about 3 miles above Philadelphia. He collected many native American plants, from which he grew seeds and plants for sale abroad and at home. He also imported many varieties of cultivated plants, the products from which were sold to enterprising planters like George Washington, who often visited the garden. John Bartram was also a good farmer on his estate of over 200 acres, growing cereals, grass, and clover, and feeding large numbers of cattle and horses. In 1769, when visited by Iwan Alexiowitz, a Russian gentleman, he said he was getting "from 28 to 36 bushels of wheat an acre; my flax, oats and Indian corn I raise in the same proportion" (*29, p. 179*).

His son, William Bartram (1739–1823), became a partner in the firm which carried on for many years the business connected with the botanic garden. The original garden contained about 5 acres, but was enlarged as the business grew. Catalogs published in 1807 and 1811 listed a large number of species and varieties of trees, shrubs, orchard and small fruits, cereals, and ornamental plants. In their search for plants John and William Bartram (*16*) traveled extensively, covering the region from Lake Ontario to New Smyrna, Fla., and from Jacksonville, Fla., to Baton Rouge, La.

Humphry Marshall (*276*) (1722–1801), a cousin of John Bartram, in 1773 established a botanic garden on his estate at Marshallton, Chester County, Pa., and published in 1785 a work on American trees, entitled "Arbustrum Americanum, or The American Grove" (*125*). On March 29, 1785, he was elected an honorary member of the Philadelphia Agricultural Society and on February 14, 1786, read a paper

before that society, entitled "Observations on Botany as Applicable to Rural Economics."

About 1750 William Prince (*292*) began to develop a commercial nursery for fruit trees, which his father, Robert Prince, had apparently started in a small way on his estate at Flushing, Long Island, N. Y., about 10 years before. This grew to be the first extensive collection of fruits in the United States. Varieties were produced by careful selection, including, for example, Prince Yellow Gage plum in 1783, and Imperial Gage in 1794. Ornamental trees and shrubs were added, and catalogs of the available plants were published. The first William Prince died in 1802. The business was then divided between his sons, Benjamin, who remained on the original place and called his nursery "The Old American Nursery", and William, who moved to a new piece of land in the vicinity and after a time called his establishment "The Linnaean Botanic Garden" (*138*).

William Prince, 2d, greatly enlarged the business. He imported trees, shrubs, and herbaceous plants from Europe, Asia, and Africa and collected many American species. His collection increased to over 4,000 species and varieties. Many of these were grown more from a love of botany and horticulture than for commercial gain.

His catalog for 1825 (*145*) contains 116 kinds of apples, 108 of pears, 54 of cherries, 50 of plums, 16 of apricots, 74 of peaches, and 255 of geraniums. In 1828 he published a treatise on horticulture (*146*). His son, William Robert Prince, working with his father, published a treatise on the vine in 1830 and a pomological manual in 1831, and, independently, a manual of roses in 1846. He introduced sorghum and was active in promoting silk culture.

In 1832 Samuel and Robert Parsons started a commercial garden and nursery at Flushing. "The Parsons Brothers were distributors of unusual plants, and were the first to bring in Japanese trees and shrubs for propagation purposes."

In 1784 John A. Binns (*225*) of Loudoun County, Va., began experiments with gypsum and after 19 years embodied the results in his treatise on practical farming (*21*). He used gypsum on corn, wheat, rye, barley, and other grains, and on bluegrass, clover, and other forage crops. His system of farming, which did much to improve the agriculture of Loudoun County, included the use of gypsum, clover, and deep plowing.

From 1770, for about 30 years, John Beale Bordley (*227*) made experiments on his estate on Wye Island near the Eastern Shore of Maryland, where he grew wheat, hemp, flax, cotton, and many kinds of fruits and vegetables. He published results of this work in his Essays and Notes on Husbandry and Rural Affairs, in 1799 and 1801 (*24*).

George Morgan settled at the close of the Revolutionary War on a 300-acre farm now a part of the campus of Princeton University. There "he was continually experimenting, now in corn, now in bees, now in methods of pest extermination." "Probably he was the first American to make a thorough study of the [Hessian fly]. He first described it in June, 1785" and later published accounts of his work on this insect in Carey's American Museum (*211, p. 21*).

William Coxe (1762–1831) "established extensive orchards on his farm near Burlington [N. J.], experimented freely with different

methods of planting and fertilizing, and met with marked success. In 1807 he had 2,000 apple trees in 70 to 80 acres of orchard." A number of his experiments between 1794 and 1806 were described in a communication, dated February 5, 1808, to the Philadelphia Society for the Promotion of Agriculture. In 1817 he published A View of the Cultivation of Fruit Trees and the Management of Orchards and Cider, which was "the first comprehensive American book on pomology" (*211, p 40*).

About 1770 Jacob Barge applied gypsum on a city lot in Philadelphia. This was observed by Richard Peters, afterward president of the Philadelphia Agricultural Society, whose farm was in what is now Fairmount Park. He procured a bushel of gypsum which, he said, "enabled me to begin my agricultural experiments; and I faithfully pursued and extended them, as I obtained more means" (*29, p. 270*).

WASHINGTON AND JEFFERSON AMONG THE LEADERS OF THEIR TIME IN OBSERVATIONS AND EXPERIMENTS RELATING TO AGRICULTURE

About 1760 George Washington (*320*) began to study agricultural problems systematically and to make experiments with a view to determining what was best to do on his lands at Mount Vernon and vicinity. He sent abroad for books on agriculture and carefully read whatever he received. He had such works as Tull's Horse-Hoing Husbandry and Duhamel's Practical Treatise of Husbandry and wrote detailed notes from them. He concluded that he ought to have a money crop in addition to tobacco and began extensive experiments with wheat. By this means "he determined that the grain would not lose perceptibly in size and weight if the wheat were cut comparatively green." He therefore decided that under the slow processes of cradling, it would be an advantage to begin cutting his wheat earlier than was the common practice. He tried soaking seed wheat in brine and alum to prevent smut and made other experiments to control the Hessian fly and rust. Because of careful selection of seed and good cultivation his wheat often weighed more than 60 pounds to the bushel. Regarding this crop he wrote, after the Revolution, "No wheat that has ever yet fallen under my observation exceeds the wheat which some years ago I cultivated extensively." Having read in Tull's book about lucerne (alfalfa), he began experiments with this plant in March 1760 and kept them up for many years. As late as 1798 he had a considerable field of this crop. He also grew clover, rye, spelt, and various grasses and vegetables which at that time were not included in agriculture in Virginia.

An experiment with fertilizers is described in his diary, April 14, 1760, as follows:

> Mixed my composts in a box with the apartments in the following manner, viz. No. 1 is three pecks of earth brought from below the hill out of the 46 acre field without any mixture. In No. 2 is two pecks of sand earth and one of marle taken out of the said field, which marle seemed a little inclined to sand.
> 3 has 2 pecks of sd. earth and 1 of river sand.
> 4 has a peck of Horse Dung.
> 5 has mud taken out of the creek
> 6 has cow dung

7 has marle from the Gulleys on the hillside, wch. seem'd to be purer than the other
8 sheep dung
9 Black mould from the Gulleys on the hill side, wch. seemed to be purer than the other
10 Clay got just below the garden
All mixed with the same quantity and sort of earth in the most effective manner by reducing the whole to a tolerable degree of fineness and rubbing them well together on a cloth. In each of these divisions were planted three grains of wheat, 3 of oats, and as many of barley, all of equal distances in Rows and of equal depth done by a machine made for the purpose. The wheat rows are next the numbered side, the oats in the middle, and the barley on the side next the upper part of the Garden. Two or three hours after sowing in this manner, and about an hour before sunset I watered them all equally alike with water that had been standing in a tub abt two hours exposed to the sun. (*320, p. 92.*)

In 1772 on a plat of fallow ground divided into strips 8 feet wide he sowed salt at the rate of 2 bushels per acre on alternative strips, after the manner of an ordinary field experiment.

Washington's experiments were interrupted by the Revolution, but when the war was over he resumed them at Mount Vernon.

Many of his experiments were made in what he called his "Botanical Garden," a plot of ground lying between the flower garden and the spinner's house. But he had experimental plots on most or all of his plantations, and each day as he made the rounds of his estate on horse back he would examine how his plants were growing or would start new experiments (*320, p. 106*).

He obtained Young's Annals and other books and carried on an extensive correspondence with Sir John Sinclair, Arthur Young, and other men at home and abroad, from whom he might get facts and suggestions which would enable him to experiment more intelligently. He was especially interested in the conservation and improvement of soils. In the absence of commercial fertilizers he made many experiments with manures, marl, gypsum, a variety of green manures, and deep plowing. He tried mud from the Potomac River and sought in vain for some mechanical device which would enable him to use such a fertilizer economically. He instituted a number of carefully planned rotations of crops. He was also much interested in improving his orchard fruits and vegetables and in growing experimentally many species of ornamental trees, shrubs, and flowering plants.

Thomas Jefferson, like Washington, showed a keen interest in the agricultural problems of his time and in improving existing methods. He was a close observer of natural phenomena in relation to farm operations and plant growth and introduced many plants useful to American agriculture.

Jefferson was interested in all useful branches of science, and, since his conception of utility was very broad, few lines of research that had developed in his day failed to receive some attention from this tireless man (*182*).

INFLUENCE OF AGRICULTURAL SOCIETIES IN PROMOTING AGRICULTURAL INVESTIGATION AND IMPROVEMENT DURING THE POST-REVOLUTIONARY PERIOD

After the Revolution, groups of men interested in the improvement of agriculture began to get together and discuss ways and means for promoting this improvement. This soon led to the formation of agricultural societies. The South Carolina Society for Pro-

moting and Improving Agriculture and Other Rural Concerns was projected in 1784. In its Addresses and Rules (*157*) it recommended to the planter in general "to select a small part of his grounds, in order to make experiments on it by various methods." The society recommended that these experiments should include plant and animal production, the contriving of implements, etc., and that written records of any experiments carried on should be kept and reports made.

The Philadelphia Society for Promoting Agriculture, organized in 1785, on the initiative of John Beale Bordley, had among its objects the promotion of improvements in agriculture. For this purpose it offered premiums (*140, p. XXVII*) for records of "actual experience" in testing various farm practices. For example, in 1791 its list of premiums included those for (1) "the best experiment of a five years course of crops"; (2) "preventing damage to crops by insects", such as the Hessian fly, (3) "the best comparative experiments on the culture of wheat, by sowing it in the common broadcast way, by drilling it and by setting the grain, with a machine, equi-distant." "Respecting experiments on the products of land, the circumstances of the previous and subsequent state of the ground, particular culture given, general state of the weather, etc., will be proper to be in the account exhibited. * * * It is recommended that reasoning be not mixed with the facts."

Joseph Cooper, a farmer in Gloucester County, N. J., made experiments with wheat from the Cape of Good Hope in 1785 and selection experiments with asparagus, lettuce, potatoes, and watermelons. He contributed papers on his work to the Philadelphia Society for Promoting Agriculture, of which he was a member.

On July 14, 1789, William Bartram read a paper before the society, in which were recorded his observations on the pea fly or beetle, and fruit curculio. As a remedy for the latter insect, he had tried "showering a plum tree with a weak solution of sea salt dissolved in water" (*17, p. 322*).

The plan for a State society for the promotion of agriculture (*25, p. XVII*), which was presented January 27, 1794, by a committee consisting of John B. Bordley, George Clymer, Timothy Pickering, and Richard Peters, included the establishment of "pattern farms" in different parts of Pennsylvania. On these farms "all foreign and domestic trees, shrubs, plants, seeds or grains may be cultivated and if approved as useful, disseminated. * * * The most approved implements may be used, and either improved by additions, or simplified to advantage. * * * The thoughts and suggestions of ingenious men may here be put in practice; and being brought to the test of experiment, their utility may be proved, or their fallacy detected."

When the New York Society for the Promotion of Agriculture, Arts, and Manufactures was formed on February 26, 1791, its rules and regulations, formulated by Robert R. Livingston, Simeon De-Witt, and Samuel L. Mitchill, stated that "the objects of investigation for the society shall be Agriculture, Manufactures, and Arts, with such subjects of enquiry, as may tend to explain, or elucidate their principles" (*155, p. iv*). The "queries" sent out began with the following question: "Have you made any experiment upon Marl?"

(*155, p. viii*). The transactions of this society for 1792 contain an account by Chancellor Livingston (*155, p. 25*) of his experiments during three years with gypsum on buckwheat, clover, rye, red clover, grass, corn, flax, and wheat. Experiments by Ezra L'Hommedieu (*155, p. 63*) with seaweed, mud from creeks and swamps, leached ashes, and fish as fertilizers are also reported.

In 1794 Livingston reported on seven experiments covering three years, which he had made with lucerne (alfalfa) on his estate at Clermont, N. Y. When the plants turned yellow he "carefully examined the roots with a microscope." "The remedy is to mow the plant; it will come up free from the disorder." He recommended cutting for green feed "whenever it will fill the scythe; for hay when it begins to blossom; if left till the blossom turns, it becomes too hard." He was not discouraged when "out of about fifteen acres which I sowed last year, but four succeeded" (*155, p. 90*).

The same year an article entitled "Experiments on Wheat, Clover and Lucerne", by John Stevens (*155, p. 207*), was published by this society. This covered a part of the experiments with cereals, clover, alfalfa, and potatoes carried on by Colonel Stevens on a farm at Hoboken, N. J., which he purchased in 1787, and which is now a part of the campus of the Stevens Institute of Technology founded by his son.

On March 30, 1795, Dr. Mitchill presented to the society some "observations on canker worms and the means of preventing their effects" (*155, p. 33*). In this paper he expressed the belief that "the investigation of whole way of life may lead us possibly to some method of destroying it, or at least of preventing its destructive effects."

David Hosack (*262*) studied at Columbia College and graduated at Princeton in 1789, and in medicine at the College of Philadelphia in 1791. The next year he went to England and Scotland and returned to this country in 1794 with the first collection of minerals and a duplicate collection of plants from the herbarium of Linnaeus. He became professor of botany in Columbia College in 1795 and also of materia medica in 1797. The syllabus of his course in botany, published in 1795 (*96*), includes lectures on the anatomy, chemical analysis, and food of plants, and on soils, manures, and natural and artificial propagation. He also treated of "plants useful in diet, medicine, agriculture, etc., with practical observations." In 1801 he purchased 20 acres of land in New York City, between 47th and 51st Streets and 5th and 6th Avenues, and named this tract the Elgin Botanic Garden (*26*). Here he brought together during the next 10 years nearly 1,500 species of American plants and many from Europe and the East and West Indies. He published catalogs of this collection in 1806 and 1811 (*97*). By an act of the State legislature this garden was transferred to the State of New York in 1810 and 4 years later was granted to Columbia College. No funds were provided for its maintenance, and therefore it was soon abandoned. In his later years Dr. Hosack had an estate at Hyde Park on the Hudson River, where he engaged in farming, had improved breeds of cattle, sheep, and swine, and grew fruits and botanical plants.

The Massachusetts Society for Promoting Agriculture (*65, 128*) was incorporated March 7, 1792, "for the purpose of promoting use-

ful improvements in Agriculture." At a meeting held March 11, 1793, a premium of $50 was offered for "the most satisfactory account of the Natural History of Canker Worms." This was given to William Dandridge Peck (*290*, *291*), of Kittery, in 1795. In February 1794, "a committee was appointed to consider the expediency of procuring a piece of ground for the purpose of agricultural experiments." Peck continued his studies of insects and between 1799 and 1819 published articles in the journal of the society on the cherry slug and on insects attacking pear, locust, pine, and oak trees.

In March 1797 a committee, of which Charles Vaughan was a member, was appointed "to form a table of the times of the leafing and blossoming of forest trees and shrubs, and of the leafing, blossoming and ripening of fruit trees and plants." Six hundred copies of a table prepared by James Winthrop, of Cambridge, were printed in 1803 and distributed to members of the legislature and to others "of scientific turn of mind."

In 1800 Robert Dodge was awarded a premium for an account of the growing of nearly 4,000 forest trees from seed.

In 1801 the society subscribed $500 for the establishment of a professorship of natural history at Harvard College, and a committee was appointed to procure subscriptions for its permanent endowment and for the support of a botanic garden. The professorship was established in 1804, and the trustees of the society were made the visitors of this department. This arrangement continued until March 1831. Peck was elected to this professorship and served until 1822. He was a graduate of Harvard College in 1782. In March 1805 the legislature granted the society a township of land for endowing this chair. This was sold in 1810 for $7,000. Meanwhile another township had been granted to the society for the same purpose. This was reduced to half a township when Maine became a State and was finally sold in 1834 for $15,000. The society also made annual contributions to the botanic garden established in connection with the professorship. This money was to provide "for scientific observation of the growth of vegetation and of the habits of noxious insects, that methods might be devised for their destruction, and a cultivation, for sale and distribution, of the seeds and roots of useful plants." In support of the proposition for a contribution to the botanic garden in 1811 the trustees of the society stated that it was "the opinion of the Board that the support of that institution is important to the purposes of agriculture."

In 1813 when the legislature gave the society $1,000, it devoted $600 to the use of the botanic garden, "1st, to introduce into cultivation as many native plants as possible; 2d, to devote an acre of land to raising seeds of culinary vegetables for distribution," and also "to have specimens of fiorin grass, oat grass, woad, and any other plants rare and curious."

The Society for Promoting Agriculture in the State of Connecticut was formed in 1794, and a volume of its transactions was published in 1802. The following statement regarding it is taken from the recent history of Connecticut agriculture, by E. H. Jenkins (*106*):

> Its members were invited to make experiments in the various departments of Agriculture and the constitution of the Society contemplates the free communication of that information which experimental practical farmers are

constantly acquiring. Many experiments have been made by the members themselves, and their observation has extended to the improvements of their neighbors; the queries which were framed by the Society were distributed to stimulate a spirit of investigation and the report of useful facts to the Society, that they might be preserved for general use. "This Society shall reject all doubtful or suspicious facts in communications made to the Society." The queries issued by the Society cover the whole range of farm practice.

A considerable number of experiments are recorded in the transactions, and each article is signed by the contributor. The experiments were with gypsum, ashes, creek and harbor mud, farm and green manures, and fish as fertilizers, and with wheat, corn, potatoes, grasses, fruit trees, butter, and cheese.

In 1813 Edmund Ruffin (*297*) (1794–1865) came into possession of an extensive estate at Coggins Point, Prince George County, Va. The soil of his land was shallow, and careful management was required to conserve or increase its fertility. He began reading English works on agriculture and became convinced that more systematic attention should be given to agriculture in Virginia. About this time he became acquainted with John Taylor's system of farming set forth in Arator, which was first published in 1813, and advocated growing cultivated crops to be fed green to cattle. "The manure made by the cattle should be at once plowed under, together with the waste from the fodder. Clovers should be largely grown and plowed under to add fertility to the soil. Gypsum will increase the clover yield. Deep plowing should be the rule." After trying for 6 years to apply these principles on his plantation, Ruffin was compelled to acknowledge his failure to get good results. About this time he read in Humphrey Davy's lectures on agricultural chemistry, "If on washing a sterile soil it is found to contain the salts of iron or any acid matter it may be ameliorated by the application of quicklime." Tests of his soils did not reveal salts of iron. He then thought they might contain organic acids, but the only evidence of this was the growth of such plants as sheep sorrel on his worn-out land, while they were absent on the more fertile soils. He had close at hand on his farm an abundance of shell marl and began to experiment with this on a considerable scale in February 1818. By applying from 150 to 200 bushels of marl to the acre, he secured an increase of 40 percent over the crop on untreated land. This led to further experiments with a view to bringing the soil into such condition that it would respond favorably to the use of green manures. His method of experimenting has been summarized by W. P. Cutter, in an article in the United States Department of Agriculture Yearbook for 1895, as follows:

The experiments were continued for a long series of years, accurate records being kept of the history of each plat of ground, frequent comparisons being made between the measured yields of marled and unmarled fields. Marl was tried with and without manure, and manure was tried with and without marl. The greater the number of experiments and the more numerous the results obtained the greater proof was given that the use of marl was of great advantage. The careful manner in which the experiments were carried on shows him to rank as one of the most intelligent experimenters of his time. The investigations were not confined to mere field trials. The soil of his plantation was analyzed, the marls used were analyzed, and the results were carefully studied. He searched the literature of every age for mention of the occurrence of marl and the history of its application to the purposes of agriculture. He was familiar with foreign publications on the subject, not only reading thoroughly, but studying, comparing, and making

extracts as he found matter worthy of future reexamination. He collected information as to the character and extent of deposits of calcareous substances in his native State, and devoted much time to a study of the best and most economical methods for its exploitation. He figured carefully the cost of applying the marl, and estimated the financial returns from its use. Every line of inquiry which could possibly add to his general stock of information was carefully followed to the very end.

His reasons for the use of marl, gained from his experience and study, were two in number. He believed that the addition of marl corrected the natural acidity of the soil, and that it assisted in the preservation of organic manures from loss of the gaseous products of decomposition while hastening the decomposition itself.

The marls first used by Mr. Ruffin were valuable only from their content of lime, no phosphoric acid or potash being present; but later, and especially after his removal to his estate at Marlbourne, in Hanover County, he used greensand, called by him "gypseous earth", which contained certain amounts of potash, and probably also contained phosphoric acid. He does not seem to have recognized the value of these ingredients, basing his opinion of the value of these marls on the carbonate of lime contained (*297, p. 498*).

Ruffin's first public account of his work was in a paper read before the Prince George Agricultural Society, of which he was a member. This was published in the American Farmer, December 28, 1821, as An Essay on Calcareous Manures (*151*).

The essay was afterwards published in book form, reaching its fifth edition in 1852. From a short article of seven pages it expanded to a book of 493 pages. It is probably the most thorough piece of work on a special agricultural subject ever published in English. The treatment of the subject is historical, scientific, and practical, exhausting every source of information available. From the first publication, this essay attracted great attention, and is even now the best authority on certain phases of the subject. As a result of this and other publications by the same author, a large proportion of the farm owners in the tidewater district of Virginia were led to use marl, and, what is more important, were aroused by his example to a sense of the importance of personal attention to the needs of their estates and to details of management.

From 1833 to 1843 he published a monthly agricultural journal called "The Farmers' Register", which was largely devoted to his writings on a great variety of agricultural subjects. Through his book and his journal, and in other ways, interest in the agricultural use of marl was widely spread, especially in the Southern States, where slave labor enabled the farmers to obtain it cheaply.

In 1820 a chemical investigation of corn, by John Graham, of Harvard College, was published in the New England Medical Journal, and the same year John Torrey's study of the composition of Indian bread (tuckahoe) was published in the New York Medical Repository.

In connection with the establishment of the first New York Board of Agriculture in 1819, Elkanah Watson (*321*) made a plan for a "pattern farm", which included experiments by a professor of agriculture, working under direction of the board, and Jesse Buel's plan for an agricultural school in New York, first published in 1823, included experiments to be conducted on the school farm.

The early colonists brought domestic animals of various kinds and breeds from Europe, and made efforts to improve them by crossing and by new importations from time to time. Washington, for example, gave considerable attention to the breeding of better

horses, mules, and sheep. The sheep industry was greatly stimulated during 1801 and 1802 by the bringing of Merino sheep from Spain and France to New York by Dupont de Nemours and Delessert, and Robert R. Livingston, Minister to France; to Massachusetts by Seth Adams; and to Connecticut by David Humphreys, Minister to Spain.

IMPROVEMENT OF AGRICULTURAL IMPLEMENTS

The agricultural implements introduced from Europe and used by the American colonists were crude and clumsy and often poorly adapted to the more extensive farm operations conducted here. Little was done, however, to improve them until about the beginning of the nineteenth century. According to W. H. Brewer the most important improvements in agricultural machinery between 1776 and the introduction of the cast-iron plow were the American cradle and the fanning mill for cleaning grain and other seeds.

Thomas Jefferson was so impressed with the need of improving the clumsy wooden plow commonly used that he undertook to work out the mathematical principles on which mould boards should be made, and his ideas were tested in practice about 1793 (*150*). Charles Newbold, of Burlington, N. J., made the first American cast-iron plow and had it patented in 1797 (*150*). In 1814 Jethro Wood obtained a patent for an iron plow and in 1819 for its improved form, which had interchangeable parts. The iron plow was much improved by Joel Nourse and partners, of Massachusetts, in 1836. "Apparently the steel and wrought iron plow was patented in 1808. a sidehill plow in 1831, the coulter attachment in 1834" (*106, p. 387*). John Lane in 1833 and John Deere, of Illinois, in 1837, built steel plows.

McCormick began the invention of the grain reaper in 1809, but a serviceable machine was not patented until 1834.

EARLY STATE GEOLOGICAL AND AGRICULTURAL SURVEYS (*79, 130*)

The relations of geology to agriculture were definitely recognized in the early geological surveys, and much of the later agricultural research had its beginnings in such surveys. The first report of the New York Board of Agriculture, published in 1821 (*20*), contained an account of a geological survey of Albany County, by Amos Eaton and T. Romeyn Beck, who were employed by Stephen Van Rensselaer. Eaton was employed in 1820 to make a geological and agricultural survey of Rensselaer County; and in 1822, with the cooperation of Edward Hitchcock, of Amherst College, and others, this was extended to include a survey from Boston to Lake Erie over a belt 50 miles wide. The published report of this work contains analyses of soils and accounts of methods of culture of agricultural crops (*56*).

In North Carolina the board of internal improvements, established in 1819, made surveys of a number of swamps in the eastern part of the State with reference to the practicability and cost of their drainage. In 1821 Denison Olmsted, of Connecticut, then pro-

fessor of chemistry, geology, and mineralogy at the University of North Carolina, proposed to this board a geological and mineralogical survey of the State which would include a report on gypsum and marls. This was authorized by an act of the legislature in 1823 and was carried on under direction of Professor Olmsted for 4 years. Reports were made on the occurrence and use of marls.

In 1851 Ebenezer Emmons became State geologist and in 1858 published an account of the agriculture of the eastern counties (*60*), which dealt with soils, fertilizers, grasses, and other crops. This was followed in 1860 by a report on the agriculture of North Carolina (*61*), containing a statement of the principles upon which the practices of agriculture, as an art, are founded.

The first regularly organized State geological survey in this country was undertaken in Massachusetts under Resolves of June 5, 1830, and succeeding years up to 1841 (*89*). Edward Hitchcock, of Amherst College, was in charge of this survey and made the first report January 1, 1832. The plan of work included (1) economic geology, (2) topographical geology, (3) scientific geology, and (4) a catalogue of native minerals and botanical and zoological production. Several specialists in botany and zoology were employed. The report of 1838 (*90*) contained a large number of physical and chemical analyses of soils and statements regarding their agricultural values. The final report on the biological studies, in 1841, covered 1,385 pages and included monographs on insects injurious to vegetation, by T. W. Harris; on herbaceous plants, by Chester Dewey; on quadrupeds, by Ebenezer Emmons; on fishes and reptiles, by D. H. Storer; and on birds, by W. B. O. Peabody.

In 1835 the Massachusetts Agricultural Society proposed an agricultural survey of the State, and in response to its appeal the legislature passed an act in 1837 providing for a commissioner to "collect accurate information of the state and condition of agriculture, and every subject connected with it; point out the means of improvement; and make a detailed report." Henry Colman was appointed commissioner and in his prospectus of the survey included "chemical analysis of soils, mineral manures found in the State, botanical productions, insects and worms affecting crops and forest trees." But since the legislature had previously made provision for mineralogical, geological, botanical, and zoological surveys, it was decided that such matters should be treated only incidentally in the agricultural survey. In particular the chemical analysis of soils was a part of the work of the geological survey.

As part of his work Commissioner Colman visited farms in different parts of the State and especially inspected any improvements being made in cultivation, drainage, seeds, crops, farm buildings, utensils, and livestock. He issued four reports between 1838 and 1841 (*32*), when the act creating his office was repealed. Three of these reports dealt with the agriculture of Essex, Berkshire, Franklin, and Middlesex Counties and, besides descriptions of agricultural conditions, contained accounts of experiments in diking salt marshes, planting potatoes, cultivating wheat, using lime, subsoil plowing, draining, irrigating, and using cotton waste and seed from Lowell mills as a fertilizer. There was a botanical list of grasses found in Berkshire County, and a long abstract of the American edition of

Liebig's Organic Chemistry in its Application to Agriculture and Physiology, which had been prepared by John W. Webster, professor of chemistry in Harvard College.

The final report, published in 1840, was on wheat and silk. This grew out of a request by the State senate for a report on wheat with reference to the effect of a State bounty on the yield. At that time the average yield was from 10 to 15 bushels per acre in different parts of the State. The report on silk was added by Commissioner Colman because of the considerable interest in that subject. He also gradually expanded his work to include agricultural statistics and other matters now commonly dealt with by the State Department of Agriculture.

As a substitute for the agricultural survey the legislature required that the agricultural societies receiving State funds make annual reports to the secretary of state, and from 1845 that these reports should include statements of experiments locally made. This led to the establishment of the State Board of Agriculture in 1852.

In Tennessee, Gerard Troost, a Dutch physician, chemist, and geologist, who had come to the United States in 1810, was appointed professor of chemistry, geology, and mineralogy in the University of Nashville in 1825. He had previously made and published A Geological Survey of the Environs of Philadelphia (*171*), in which he gave the chemical composition of the soils. Under an act of December 21, 1831, he became State geologist and mineralogist in Tennessee, and continued in this work until 1848. He made nine reports, in which much is said about the soils of the State and their suitability for grass and different crops.

In Maryland, legislative resolutions of March 18, 1833, provided for a State engineer and a geologist to make a reconnaissance with reference to a future survey. J. H. Alexander was appointed engineer, and J. T. Ducatel geologist. In their report (*55*) they stated that in their opinion "by a Geological Survey is meant not only an inquiry into the mineral constitution of the different sections of the State, but a development of all its resources, in as far as these are dependent upon the occurrence within its territory of such substances belonging to the soil, as have already been, or are capable of being, applied to useful purposes in Agriculture, Manufactures and the Arts." An act of February 25, 1834, authorized the survey, and the work was put in charge of Alexander and Ducatel. The first report (*55*) contained data on marls and miscellaneous agricultural resources of the Eastern Shore. Subsequent reports included information on shell and stone lime in different parts of the State.

An account of a meeting of the Maryland Farmers' Club (*126*) on December 13, 1845, shows that Ducatel was "resident geologist and analytical chemist to the club", which also had a professor Baer as the "lecturing and practical agricultural chemist." The club wanted information about a troublesome disease of potatoes and asked Professor Baer to analyze a pound each of healthy and diseased potatoes. His report in April 1846 records his analyses and his conclusion that the disease was "a putrefactive fermentation, produced by the condition of the atmosphere and improper cultivation."

In December 1847 a State agricultural chemist was provided for in a special act, to analyze each variety of soil and marl or other

vegetable or mineral deposit. James Higgins first filled this office; and his first report, published in 1850, treated of constituents of soils, manures, marsh mud, lime, potash, phosphoric acid, guano, etc., with special attention to the soils of the Eastern Shore. Five other similar reports were issued from 1852 to 1858 (*83*).

In New Jersey a geological and mineralogical survey was established under an act of February 26, 1835, in charge of Henry D. Rogers, professor of geology in the University of Pennsylvania. A second survey under an act of March 2, 1854, called for a full scientific and practical description of marls and soils. The State was divided into northern and southern divisions for this study. The survey in the southern division was in charge of George Hammell Cook (p. 75), a graduate of Rensselaer Polytechnic Institute in 1839 and from 1853 professor of chemistry and natural sciences in Rutgers College. His reports up to the end of this survey in 1856 contained much matter relating to agriculture, including analyses of soils, marls, and fertilizers. Under the impulse of the State Agricultural Society an act of March 30, 1864, established a third survey, which was conducted by Professor Cook as State geologist.

The report of 1868 was an elaborate treatise on the geology of New Jersey (*42*). In general, the reports of the survey treated of (1) the "fertilizers found in the State and the means of making them more quickly and generally useful", (2) the marshes and tracts of land subject to protracted freshets, (3) the soils of the State, their origin, chemical and physical properties, distribution, and suggestions for their more productive management, (4) the iron and zinc ores of the State, and (5) additions to the scientific and economic geology of the State. From 1867 "agriculture" was added to the title of the professorship held by Dr. Cook, and in 1880 he also became director of the New Jersey Agricultural Experiment Station, which was then established under his leadership in the agricultural affairs of the State (p. 95).

In Virginia an act of March 6, 1835, provided for a geological reconnaissance and determination of the chemical composition of soils, minerals, and mineral waters. The work was in charge of William B. Rogers, professor of chemistry and natural philosophy in William and Mary College. His report led to the act of February 29, 1836, providing for a geological survey, including analyses of soils, marls, etc.

In New York the act of 1836 calling for a geological survey of the State provided that it should include "a full and scientific description of its rocks, soils and minerals and of its botanical and zoological productions." The State was divided into four districts for the survey. In the second district the work was in charge of Ebenezer Emmons, a graduate of Williams College in 1818 and of Rensselaer Institute, under Amos Eaton, in 1826. James Hall, also a graduate of Rensselaer Institute in 1832, had the fourth district. John Torrey was in general charge of the botanical work. This first survey came to an end with the report in 1842. Thereafter, Hall began a comprehensive study of the paleontology of the State, and Emmons undertook an elaborate survey of its agriculture, the results of which were published in five large volumes between 1846 and 1854 (*59*). These contained an account of the classification, composi-

tion, and distribution of the soils and rocks and of the climate and agricultural productions of the State, together with descriptions of the more common and injurious species of insects. There were numerous illustrations in black and colored plates.

On May 4, 1854, Asa Fitch, Jr., a graduate of Rensselaer Institute in 1827, was appointed to make an entomological survey of New York under the direction of the State Agricultural Society. His first report, on fruit insects, was made March 14, 1853 (*67*). He continued in this work until 1871.

In Maine the acts of March 21 and 28, 1836, provided for a survey which was primarily to determine the resources of public lands belonging to Maine and Massachusetts. The latter State joined in the survey. It was afterwards broadened to include the whole State of Maine. Charles T. Jackson was in charge of this survey, which was under the board of internal improvements. His second (*104*) and third (*105*) reports in 1838 and 1839 contained chapters on the agricultural geology and agricultural resources of Maine. A second survey of the State under an act of March 16, 1861, was made by the State Board of Agriculture (*92, 93*). It was "to embrace its geology, agriculture, natural history and physical geography." On its staff were the following specialists: Ezekiel Holmes, naturalist; C. H. Hitchcock, geologist; G. L. Goodale, botanist and chemist; A. S. Packard, Jr., entomologist. The two publications resulting from this survey contained a general report on the natural history, agriculture, and geology of the State and a special report on the geography, agricultural capabilities, geology, botany, and zoology of the wild lands.

In Delaware an act of February 13, 1837, provided for a geological survey under three commissioners. J. C. Booth was put in charge and made one report (*23*). He gave principal attention to greensand and shell marls and "assumed duties of a traveling instructor in agriculture."

Michigan, immediately after admission to the Union, passed an act February 23, 1837, calling for a geological survey, to include a study of rocks, soils, minerals, and botanical and zoological productions. Douglas Houghton was in charge, and his first report was on salt deposits. The next year the survey was divided into four departments—geology and mineralogy, zoology, botany, and topography. Houghton claimed the following benefits of the survey: (1) It disseminates knowledge of soils, (2) it shows how to correct deficiencies in them, (3) it reveals mineral manures, (4) it accumulates information about destructive insects, and (5) it disseminates knowledge of plants, useful and noxious.

In Indiana an act of February 6, 1837, and in Ohio an act of March 27, 1837, provided for geological surveys, which were to include analyses of soils.

In New Hampshire an act of June 24, 1839, provided for the appointment of a State geologist to make a survey of the State. This act continued in force until July 1, 1843. Charles T. Jackson was appointed to this position. His final report was made in June 1844 (*103*) and contains a chapter on agricultural geology and chemistry, observations made on a number of farms, analyses of soils, etc.

In South Carolina an act of 1842 authorized a geological and agricultural survey, with special reference to the examination of soils,

marls, lime, etc. Edmund Ruffin, of Virginia (p. 10), spent a short time in charge of this survey and made a report in 1843 (*183, p. 57*), which dealt chiefly with marls as soil stimulants and contained analyses of such substances found in the State.

During the next 3 years the survey was in charge of M. Tuomey, who published in 1848 The Geology of South Carolina (*184*). This included a record of the very important discovery that the marls of the State contained phosphate of lime. This discovery was made by Charles U. Shepard, professor of chemistry in Amherst College and in the Medical College of Charleston. In an address before the South Carolina Medical Society, Professor Shepard told of his discovery, as follows:

In April, 1845, my attention was directed to the cause of the fertility of the marl found in the immediate vicinity of this city; and I was led to ascribe it to the extraordinary proportion of phosphate of lime I found it to contain. * * * My results were published at the time in the Southern Agricultural Journal, vol. 5, p. 133, new series (*153*).

Afterwards J. L. Smith obtained similar results upon the same marls. Dr. Shepard and L. W. Hatch were preparing to utilize the phosphatic marls near Charleston when the Civil War broke out and stopped their enterprise. After the war the marls were mined on a large scale.

In Vermont an act of October 28, 1844, authorizing a geological and mineralogical survey, made provision for an examination and description of rocks, soils, metals, and minerals. C. B. Adams, of Middlebury College, and Edward Hitchcock, of Amherst College, conducted this survey. The scope of the work was enlarged by an act of 1853 to include botany and agriculture. The second survey was in charge of Professor Hitchcock from 1856 to 1860. He reported that "first and most important of all" among its results was the discovery that the agricultural capabilities of the soils of Vermont were due to the presence "of lime in such a state of natural processes to bring it out in just about the quantity needed for vegetation" (*91*).

In Alabama the first act providing for a geological survey was passed in January 1848, and the later act of February 3, 1854, provided for the determination of the quality and characteristics of soils and their adaptation to agricultural purposes and, in general, everything relating to the geological and agricultural character of the State.

In Mississippi an act of March 5, 1850, for the further endowment of the University of Mississippi, provided that at least half the appropriation should be used for a geological and agricultural survey of the State; and in an act of March 1, 1854, the university was directed to make analyses of soils, marls, and mineral waters and report the results to the State geologist, who at that time was B. L. C. Wailes, of Jefferson College. His report for that year contains a treatise on the agriculture of the State, especially cotton growing, with analyses of marls, cotton, ashes, etc. E. W. Hilgard became an assistant in this survey in 1855 and explored the northeastern portion of the State, giving special attention to the surface features, including plants, soils, marls, and water supply (*86*). He became State geologist in 1858, while a professor in the University of Mississippi.

In Wisconsin the first geological survey was under an act of March 25, 1853, which included provision for an analytical and experimental chemist. An act of March 3, 1857, made James Hall, Edward Daniels, and Ezra S. Carr commissioners to conduct a geological, mineralogical, and agricultural survey. This included analyses of soils and subsoils, their adaptation to particular crops, and the best methods of preserving and increasing their fertility. There were to be collections of soils, native fertilizers, and cultivated and other useful plants. Carr was a graduate of the Rensselaer Institute in 1838 and professor of agricultural chemistry at the University of Wisconsin.

Before the establishment of the first agricultural experiment station in the United States, there were geological surveys in about 30 States. Most of these surveys collected and published data directly relating to the agriculture of their respective States. They thus laid a considerable foundation for the more intensive work of the experiment stations with soils and fertilizers in their relations to plant growth.

RELATIONS OF THE NATIONAL GOVERNMENT TO AGRICULTURE, 1796–1835

It was fitting that the first movement for aid to agriculture by the National Government should be inaugurated by George Washington. As a practical farmer he read the agricultural literature of his day and carried on experiments on his own farm. He was a visitor at John Bartram's botanic garden near Philadelphia and as an honorary member of the Philadelphia Agricultural Society was in close touch with Richard Peters and other men who were seeking to promote public interest in the improvement of agriculture. As president of the United States he naturally desired to do something for this basic industry. It is therefore not surprising that as the result of correspondence in 1789 with Baron Pöllnitz, a German nobleman who was conducting experiments, especially with agricultural machines, on a farm near Broadway and Tenth Street, New York City, Washington was led to suggest to Congress in his message of 1790 that it would be well to encourage agriculture, as well as commerce and manufactures. Pöllnitz thereupon suggested to Washington the establishment of an experimental farm under Government patronage. Washington was not ready to do this and replied that Congress should decide what measures ought to be adopted for promoting the great objects he had called to their attention.

In 1793 the British Board of Agriculture was established and was ably managed by Sir John Sinclair. Washington was greatly interested in the operations of this board and carried on a long correspondence with Sinclair. Learning in the summer of 1796 that Washington was about to retire from the presidency, Sinclair wrote him urging that he recommend—

> some agricultural establishment on a great scale, before you quit the reins of government. By that I mean a Board of Agriculture, or some similar institution, at Philadelphia, with societies of agriculture in the capital of each State, to correspond with it.

Washington then consulted Alexander Hamilton and John Jay and asked their "joint opinion." In his last message, delivered December 7, 1796, Washington, after referring in general terms to the importance of agriculture, recommended the establishment of a National board of agriculture, as follows:

In proportion as nations advance in population * * * the cultivation of the soil [becomes] more and more an object of public patronage. Institutions * * * grow up supported by the public purse. * * * Among the means which have been employed to this end none have been attended with greater success than the establishment of boards composed of proper characters charged with collecting and diffusing information, and enabled by premiums and small pecuniary aids to encourage and assist a spirit of discovery and improvement. This species of establishment contributes doubly to the increase of improvement by stimulating to enterprise and experiment and by drawing to a common center the results everywhere of individual skill and observation and spreading them thence over the whole nation (22).

Washington sent full information regarding this matter to Richard Peters and virtually asked that it be taken up with Congress by representatives of the Philadelphia Agricultural Society. Timothy Pickering, then Secretary of State, favored the proposition, and it was received with much interest by many influential people.

EARLY CONGRESSIONAL ACTION

On December 10, 1796, the following response to Washington's recommendation, drawn by Senator Read of South Carolina, was read in the Senate:

The necessity of accelerating the establishment of certain useful manufactures by the intervention of the legislative aid and protection and the encouragement due to * * * the creation of boards (composed of intelligent individuals) to patronize this primary pursuit of society are subjects which will readily engage our most serious attention (22).

The House of Representatives on December 16 referred the matter to a special committee of three, which reported January 11, 1797.

That the encouragement of agriculture is an object highly worthy the public attention, as it constitutes the most useful employment of our citizens, is the basis of manufactures and commerce, and is the richest source of national wealth and prosperity. The present situation of the United States opens the fairest prospect to agricultural improvements, and invites the attention of the Legislature to so interesting and important an object. * * *

The only method which a Government can with propriety adopt, to promote agricultural improvement, is to furnish the cultivators of the soil with the easiest means of acquiring the best information respecting the culture and management of their farms, and to excite a general spirit of inquiry, industry, and experiment. This object can be best attained by the institution of societies for the encouragement of agriculture and internal improvement; a practice which has been already sanctioned by the experience of other countries.

Societies have been established in many parts of the United States, but are on too limited a scale to answer the great national purpose of agricultural improvement throughout the United States; it is, therefore, necessary that a society should be established, under the patronage of the General Government, which should extend its influence through the whole country, and comprehend the extensive object of national improvement.

* * * * * * *

It will be a common center to unite all the institutions in the United States, and will strengthen the bond of union; it will be a deposit to receive and preserve all the discoveries and improvements which shall be made by the experiments of individuals or societies in every part of the world; whence

the result of the whole, after it has been digested by the society, may be disseminated throughout the United States, and every part of the country become acquainted with the best mode of husbandry.

* * * * * * *

Such a society, by proposing honorary rewards or pecuniary premiums for valuable discoveries and experiments, might excite a general spirit of improvement in the country, and, by the exhibition of specimens of culture, might promote and extend their adoption. Gentlemen of science and fortune, concerned in farming, would be ambitious to make experiments when there was a society to which they might communicate their discoveries, and by the instrumentality of which they might be rendered a public advantage. Their example would be imitated and their improvements adopted by those in their vicinity who wanted the pecuniary means or the enterprising spirit necessary for a course of experiments, and in this way all valuable improvements might easily be spread through the country.

* * * * * * *

It is believed that no provision from the public Treasury need be made, excepting for the salary of a secretary and for stationery, which will not be sufficient to constitute any objection to the institution. But if the state of the Treasury should render this unadvisable, it is beyond a doubt that the institution might be supported without any public pecuniary aid (*191*).

The committee recommended the creation of The American Society of Agriculture, with a secretary paid by the Government and with headquarters at the National Capital. Senators, Representatives, Judges of the Supreme Court, the Secretaries of State, Treasury, and War, and the Attorney-General were to be members ex-officio, "and such other persons as should choose to become members agreeably to the rules prescribed." The society was to hold annual meetings, at which officers would be elected and also a board, to consist of not more than 30 persons, which should be called "The Board of Agriculture." The society was to be incorporated. Annual reports were to be made.

It was provided that the society "may encourage experiments and discoveries, by honorary rewards; they may take the necessary measures to obtain a statistical survey of the United States", and that the board—

shall take proper measures to obtain information of the state of agriculture in the United States; they may correspond with and receive communications from similar institutions in foreign countries, as well as from private associations and individuals. * * * They shall cause to be published the result of all the information, experiments, and discoveries, which shall be communicated to them and shall distribute the same throughout the United States. * * * All communications to the society or board, or from them, shall be free from postage.

The bill embodying this plan carried also a proposition for the establishment of a military academy. A discussion arose regarding direct taxes, and Jefferson openly opposed the recommendation for a military academy on the ground that "none of the specific powers given by the Constitution to Congress would authorize it." He had great interest in the advancement of agriculture and was lukewarm toward the promotion of other industries. But that he could not bring himself to support Washington's proposition for a Federal agricultural agency is shown by his letter to Livingston in February 1801 with reference to the proposal to incorporate a central agricultural society. "I am against that", he wrote, "because I think Congress can not find in all the enumerated powers any one which authorizes the act, much less the giving of public money to that use."

The bill was brought up for consideration in the House, but the friends of the measure apparently feared to bring it to a vote, and the session closed without further action. In writing to Sinclair, Washington said it was "highly probable that next session will bring this matter to maturity", but nothing further was done about it.

Twenty years later a petition drawn up by Elkanah Watson in 1816 asked—

that the aid of the National Government may be extended to the promotion of the interests of agriculture and manufacturing, either by the establishment of a national board, or by such means as in the wisdom of Congress may seem meet and proper.

The petition was presented in the House of Representatives January 29, 1817, by John W. Hulbert, Representative from Massachusetts, at the request of the president of the Berkshire Association for the Promotion of Agriculture and Manufactures. It was referred to a special committee of which Hulbert was chairman. On February 21 this committee reported a bill establishing such a board. It was read twice but no further action was taken. It was thought that President Madison was opposed to the measure on account of constitutional limitations and there was much objection to extending the functions and expenditures of the Federal Government.

Congress, however, felt that it had full control of the public lands and in 1817 provided—

for the allotment of certain lands within what was then known as the Mississippi Territory to French immigrants for the purpose of promoting the cultivation of the vine and the olive. In 1838, in recognition of services in introducing useful tropical plants into the United States, Congress granted to Henry Perrine and his associates a body of land in the southern extremity of the Peninsula of Florida for the propagation and cultivation of such plants (*195*).

Growing public interest in matters relating to agriculture led the House of Representatives to establish a Committee on Agriculture May 3, 1820, and in 1825 the Senate created a similar committee. For a long time, however, these committees were "little more than convenient repositories for such petitions, memorials and other documents relating to agriculture as might come before Congress."

On May 11, 1826, the House passed a resolution calling upon the Secretary of the Treasury to furnish information on the growth and manufacture of silk, as adapted to different parts of the Union. This led to an extensive inquiry on this subject and the preparation of a manual of 220 pages, under direction of Richard Rush, Secretary of the Treasury, which was published in 1828 as a House document (*190*). Count von Hazzi of Munich, Germany, having seen a copy of the House resolution regarding silk, transmitted to Congress through James Mease, A Treatise on the Rearing of Silk Worms, which was also published as a House document in 1828 (*189*).

In 1820 Congress granted 5 acres in the District of Columbia to the Columbian Institute for the Promotion of Arts and Sciences as a botanic garden and afterwards allowed the use of a room in the Capitol (*148*).

On January 25, 1830, the House of Representatives passed a resolution instructing the Secretary of the Treasury "to cause to be prepared a well digested Manual, containing the best practical information concerning the culture of the sugar cane, and the fabri-

cation and refinement of sugar, including the most modern improvement." This investigation was committed to Benjamin Silliman (*304*), of Yale College, who was assisted by C. U. Shepard and O. P. Hubbard. The cane-growing districts in Louisiana, Georgia, and Florida were visited, as well as the establishments north and south where sugar was made and refined. The final report was made May 28, 1833, in the form of a Manual on the Cultivation of the Sugar Cane, and the Fabrication and Refinement of Sugar (*154*). It contains an account of the botany of sugarcane, the chemistry of cane juice, the methods of culture of this crop, and the processes of making and refining the sugar.

ADVANCEMENT THROUGH EXECUTIVE BRANCHES OF THE GOVERNMENT

Meantime the executive branches of the Federal Government had for a long time been aiding the advancement of agriculture. In this they were following the example of Franklin, who, before the Revolution, while he was the agent of Pennsylvania in England, sent home silkworm eggs and mulberry cuttings to start silk growing. Consuls and naval officers from time to time sent seeds and cuttings, and aided in introducing new breeds of animals. "During Washington's last administration William Eaton, consul at Tunis, sent to Timothy Pickering, Secretary of State, several Barbary sheep" (*77, p. 7*) in a naval vessel. A pair of these sheep were given to Richard Peters, whose farm was near Philadelphia, and thence the breed spread through Pennsylvania and adjoining States. In 1810 William Jarvis, consul at Lisbon, took advantage of the Napoleonic wars and bought from Spanish noblemen thousands of purebred Merino sheep for shipment to this country. In a similar way Chinese and French hogs were introduced here early in the nineteenth century. On March 26, 1819, William H. Crawford, Secretary of the Treasury, sent a circular letter (*115, 199*) to all the consuls, asking them to procure useful seeds, plants, and inventions, and arrangements were made for the cooperation of collectors of ports in distributing these. "No expense can be authorized," he wrote, but "it is possible that the attention of the national legislature may be attracted to the subject, and that some provisions may be made, especially in relation to useful inventions." Again in the administration of John Quincy Adams (1825–29), who in his message to Congress December 6, 1825, favored legislation for the promotion of agriculture, directions were given to consuls to forward rare plants and seeds for distribution.

AGRICULTURE PROMOTED THROUGH THE PATENT OFFICE, 1836–62 (*187, 200*)

The first law providing for patents was enacted in April 1790 and the records of patents were thereafter deposited in the State Department. When the business relating to patents became considerable, a clerk to attend to it was appointed, and he was designated Superintendent of Patents. On May 12, 1835, Henry L. Ellsworth (fig. 1), of Connecticut, was appointed to this office by President Jackson. In his first report he recommended that a separate bureau should be

created to transact the rapidly growing business. As a result, Congress passed the act of July 4, 1836, creating the Patent Office as a branch of the State Department. Mr. Ellsworth was immediately appointed Commissioner of Patents, and took this office July 6, 1836.

THE FIRST COMMISSIONER OF PATENTS

Henry Leavitt Ellsworth (*246*, *247*) was born at Windsor, Conn., November 10, 1791. He was a son of Oliver Ellsworth, who was a member of the convention which framed the Constitution and afterwards Chief Justice of the United States Supreme Court in Washington's administration. His home was on a farm at Windsor, and his interest in agricultural advancement was shown by his publishing in the Connecticut Courant from 1804 to 1806 a column headed "The Farmers' Repository."

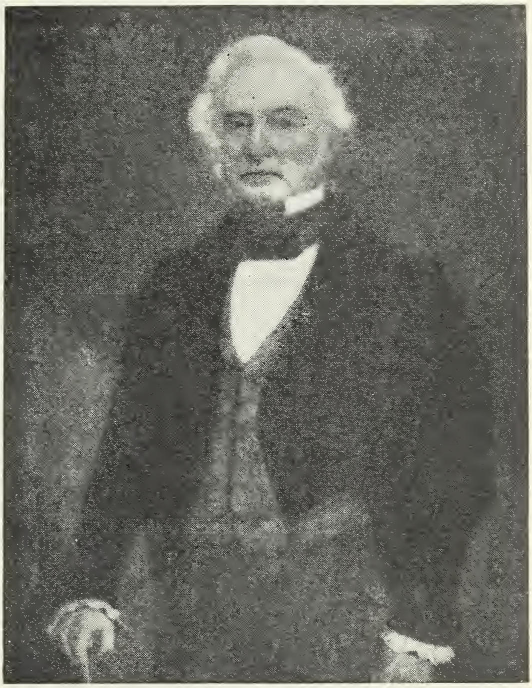

FIGURE 1.—Henry Leavitt Ellsworth, 1791–1858.
Commissioner of Patents, 1835–45; he helped to lay the foundations for the present Department of Agriculture.

Ellsworth graduated at Yale in 1810 and then studied law. For a time he practiced law, but, preferring a more active career, he engaged in farming and commercial business. In 1832 he was appointed one of the Commissioners of Indian Affairs in the region southwest of Arkansas. He traveled in the prairie States prior to 1835 and became convinced that they had great agricultural possibilities. He therefore began to purchase, for himself and others, large tracts of public land in the region from Michigan to Iowa. The problems of kinds and varieties of crops to grow on these lands, and the need of improved implements for their culture and harvesting were deeply impressed on his mind. He had already considered such matters as they related to New England agriculture. He had been in touch with Elkanah Watson and his movement for agricultural advancement through the introduction of improved livestock and the collection and distribution of improved seeds and plants.

When the Hartford County Agricultural Society was formed in 1817 Ellsworth was its secretary, and among his publications was an address which he delivered before that society March 24, 1818. In

that address (*58*) he stated that one of the objects of the society was "to aid them [the farmers] in their labors, by the introduction of new seeds and improved implements of husbandry, and the distribution of the most valuable publications on agricultural subjects." When he was appointed Superintendent of Patents in 1835 he established a headquarters for his land operations at La Fayette, Ind., and put one of his sons in charge of this business. It is therefore easy to see why Ellsworth was profoundly interested in the Patent Office where were the numerous and constantly growing records of inventions of agricultural implements and processes. But he was not content with this office as he found it. As an energetic business man he brought order out of the chaos which apparently existed there, and proceeded to secure for the office a higher official status and a broader range of work.

When a fire in 1836 wrecked the building in which the patent models and records were kept and destroyed its contents, Ellsworth brought about the erection of the first unit of the great Patent Office building, which was planned to be used in part as a museum, and advocated that courses of lectures on agriculture and its scientific relations be given there. He attempted to have some of the Smithson bequest devoted to this purpose.

On leaving his position in Washington in 1845 he settled at La Fayette, Ind., where he was United States Land Commissioner and a promoter of land purchases and settlement on a large scale. His holdings in Benton County, Ind., alone, are said to have aggregated at one time 65,000 acres. He kept up his interest in the general agricultural affairs of this region and in 1852 was the first president of the Tippecanoe County Agricultural Society. Economic conditions made the management of his landed enterprises increasingly difficult, and in April 1858 ill health compelled his removal to Fairhaven, Conn., where he died December 27, 1858. He left two wills which led to a legal contest in which Yale and Wabash Colleges and other parties engaged. The question of his sanity was involved, and one reason alleged for doubting this was his prediction that steam would one day be used as the power to draw plows and other agricultural machines on the prairie farms.

Ellsworth, as Commissioner of Patents, immediately began to collect from various sources "new and valuable varieties of seeds and plants", and to distribute these with the aid of Congressmen and others. Naval officers, consuls, and private citizens traveling abroad were frequently bringing to this country seeds and plants which might be used in our agriculture but which were largely lost because there was no agency for their preservation and distribution. In his report for 1837 Ellsworth therefore suggests the creation of a public depository for such articles, "whence they may be dispensed to every part of the Union."

This part of the Commissioner's report was referred to the Committee on Agriculture of the House of Representatives, together with a resolution on this subject introduced March 5, 1838. Two days later Congressman Joseph F. Randolph, of New Jersey, made a report from this committee favoring this project and introducing a bill which would appropriate $5,000 to create an agricultural depository in the Patent Office and provide "a clerk to be denominated the

agriculturist at $1,600 and two laborers." This appropriation had been suggested in a letter of the Commissioner dated February 22, 1838. The committee's report calls attention to the embarrassment which had resulted from the loss of seeds and plants stored in customhouses and elsewhere which had been brought to this country in obedience to a Treasury Circular of September 6, 1827, requiring consuls to collect and transmit seeds and plants, with information regarding climate, soil, propagation, cultivation, insect pests, and uses, and agricultural literature. The Secretary of the Navy had asked naval officers to assist in this work.

Congress did not pass this bill, and Ellsworth's efforts to aid agriculture without authority from Congress seem to have aroused criticism. This led to a letter from the chairman of the House Committee on Patents January 21, 1839, asking for information "relative to the collection and distribution of seeds and plants; also the practicability of obtaining agricultural statistics." In his reply, January 22, 1839, Commissioner Ellsworth defends his action, points out the good results which had followed the distribution of certain varieties of corn, and asks for a small appropriation from the patent fund for seed distribution in order that he may be relieved from expenses "already becoming onerous to himself individually." He also expresses a willingness to collect and report agricultural statistics.

In the Appropriation Act of March 3, 1839, Congress granted $1,000 from the Patent Office fund for the collection of statistics and for other agricultural purposes. Since agricultural inquiries were included in taking the census of 1840 the Patent Office spent very little of its appropriation for that purpose.

In 1840 more than 30,000 packages of seeds were distributed. That year the Commissioner urged "the importance of an annual report of the state of the crops in different sections, as a preventive against monopoly and a good criterion to calculate the state of exchange."

On December 15, 1841, "a meeting of the friends of agriculture from the different sections of the United States was held, pursuant to public notice, in the Hall of the House of Representatives", Washington, D. C. At this meeting the Agricultural Society of the United States (*1*) was organized, having for its objects "to improve the condition of American husbandry and from its central position to serve as a medium of communication and of action with other agricultural societies throughout the Union." Among other things, the society was to make efforts to obtain funds for the establishment of an agricultural school in the District of Columbia with a course of public lectures on agriculture and the sciences, and an experimental farm. For this purpose the society made an attempt to secure the fund which was finally used for the establishment of the Smithsonian Institution, but was unsuccessful. Commissioner Ellsworth took an active part in the formation and work of this society, the movement for which had been instituted under the leadership of Solon Robinson, of Indiana. Though a number of men prominent in agricultural affairs took part in its organization, the society did not receive substantial support and came to its end after the second meeting, held at Washington, May 4 and 5, 1842.

In 1841 the Commissioner stated that "the plan of making a complete collection of agricultural implements used, both in this and foreign countries, and the introduction of foreign seeds, are steadily pursued." He strongly urged the importance of the application of the sciences, particularly chemistry, to agriculture. The analysis of soils and the extraction of oil and sugar from corn were cited as examples of the benefit to agriculture from chemical investigations. The appointment of "a single clerk" to collect agricultural statistics was suggested.

In 1842 the Commissioner pleaded for "the constitution of an agricultural bureau, or at least an agricultural clerkship", to collect and interpret agricultural statistics. He also asked for funds which would enable him to make by observation in the field a personal study of crops and agricultural implements. During the previous year he had traveled in 10 States, where he had examined the crops and had thus been better able to pass judgment on the statistics submitted to the office.

He favored the use of a portion of the Smithson fund for the lectures at Washington to farmers' sons so that they might "get a knowledge of chemistry and the arts, as will enable them to analyze the different soils and apply agricultural chemistry to the greatest effect." A stronger plea for such lectures was made in the report for 1843. Among the causes of agricultural improvement he cited the State geological surveys; the experimental work in agricultural chemistry relating to soils, manures, and crops; the increasing number of agricultural periodicals and treatises; and the growing influence of agricultural societies.

In 1843 a much larger amount of statistical and other information on agricultural subjects was included in the Commissioner's report. Special attention was given to reports on making sugar from cornstalks in different parts of the country. Fifteen thousand copies of the agricultural portion of the report were printed by order of Congress.

The report for 1844 gave an account of analyses of cornstalk sugar and kernels of corn, made under direction of Charles T. Jackson of Boston, Mass. (p. 30). There were also reports on field experiments with wheat and corn and the making and use of cottonseed oil. Much attention was given to diseases of potatoes. The growing development of a science of agriculture was pointed out, and was illustrated by extracts from Thaer's Principles of Agriculture.

In 1845 Commissioner Ellsworth resigned, and the Patent Office report for that year was prepared under direction of his successor, Edmund Burke (*231*) (1809–82), a native of Vermont, who had practiced law in New Hampshire, from which State he had served as Representative in Congress. This was a document of 1,184 pages, nearly 1,100 of which were devoted to statistics and miscellaneous information on agricultural subjects. Much space was given to potato diseases. Because of the growing volume of business relating to patents and dissatisfaction with the use of the patent fund for agricultural purposes, the Commissioner suggested that Congress make a special appropriation of other funds in the Treasury for the agricultural work of the Patent Office. The result was that Congress made no appropriation for such work in 1846. There is therefore no report for that year.

In 1847 more than 60,000 packages of seeds were distributed, including some contributed by the French minister of agriculture and commerce. In the report for that year considerable space was given to observations made by Charles L. Fleischmann in Germany in 1844–45, including accounts of the sheep industry and agricultural schools, especially Thaer's school at Moegelin. The Commissioner said that a new era seemed to be opening in agricultural education with the beginning of instruction related to agriculture at Yale, Harvard, and in Ohio, and thought that traveling lecturers could do much to diffuse agricultural knowledge.

In 1848 Congress made a special appropriation of $1,000 for "chemical analyses of vegetable substances produced and used for the food of man and animals in the United States." This involved a determination of the effect of soil and climate upon the grains and of sea voyages and of storage upon flour and meal. Lewis C. Beck, of Rutgers College, "an experienced analytical chemist", was employed to make this investigation and on December 15, 1848, made a report dealing chiefly with wheat and wheat flour. It included 33 analyses of wheat flour from different countries. Charles L. Fleischmann reported an investigation of the history, progress, and culture of sugarcane in Louisiana. Reference is made to R. S. McCulloch's report on the chemical nature of saccharine substances and the art of manufacturing sugar, published by Congress in 1847.

Under the act of March 3, 1849, creating the Department of the Interior, the Patent Office was transferred to that department. That year Thomas Ewbank (*248*) (1792–1870) became Commissioner of Patents. He was a native of England, followed the machinist's trade in his yuth, and manufactured metallic tubing in New York from 1820 to 1836, when he retired to devote himself to literary and scientific pursuits. He committed the preparation of the agricultural part of the report of the Patent Office for 1849 to Daniel Lee, editor of the Genesee Farmer in New York, and professor of agriculture at the University of Georgia. In his introduction to the report Dr. Lee emphasized the importance of agricultural education on the ground that a scientific knowledge of agriculture is essential as a basis for improved practice which will conserve the fertility of the soil. He held that among the things needed to help agriculture were studies which would aid in the control of insect pests and plant diseases; analyses of soils, marls, and fertilizers; improvements in dairy animals; better methods of preserving agricultural products used for food; distribution of better seeds and plants; and the more thorough collection of agricultural statistics with the aid of States and counties.

An effort was made to obtain more definite information regarding the experience of farmers with different varieties and kinds of crops and fertilizers. The importance of chemical studies relating to agriculture was emphasized by including in the report 71 additional analyses of wheat and flour by Professor Beck, and a compilation, from various sources, of analyses of corn, buckwheat, clover, peas, beans, flaxseed, fruit and forest trees, cottonseed and wool, and the soil of a prairie farm.

In the report for 1850 Dr. Lee had an extensive article on The Study of Soils, including their origin, composition, elements of

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fertility, chemical effects of tillage, and "the philosophy of improving soils." Edmund Ruffin contributed an article on the "management of wheat harvest", which summarized his experiments on this subject. Analyses of the apple and rhubarb, by J. H. Salisbury (p. 68) were reported. There was also a summary of Dr. Hitchcock's report to the Massachusetts Commission on Agricultural Education in Europe.

In 1851 the report contained an article by J. P. Norton (*288*), of Yale College, on The Mineral Manure Theory, in which he combated Liebig and cited experiments by Lawes and Gilbert in support of his views. The repetition of experiments and the need of field studies to supplement laboratory work are emphasized. Spencer F. Baird, of the Smithsonian Institution, contributed an illustrated article on The Ruminating Animals of North America and Their Susceptibility to Domestication. Meteorological records from different parts of the United States were given. The importance of agricultural education was emphasized in three articles. Harvey Dodge, of Sutton, Mass., proposed the establishment of agricultural schools and experiment farms in every State and a national agricultural college for education and research. Milton P. Braman, of Massachusetts, favored agricultural schools whose teachers also be investigators, and J. B. Turner, of Illinois, presented a plan for an industrial university (*185*).

Commissioner Ewbank, in an article on an Agricultural Bureau (*64, p. 653*), said that—

the institution of an agricultural bureau by the general government has been a subject of public discussion for years, and is now (as it has repeatedly been) under the consideration of Congress. The legislatures of several States have passed resolutions in favor of its organization, and so have agricultural societies in various sections of the Union. Agricultural writers have inculcated its importance, and practical men have repeatedly urged the necessity of it in their communications to this office. Presidents Taylor and Fillmore have followed the example of Washington in calling the attention of Congress to the subject. All that has been done towards carrying these views into effect is the employment of a temporary clerk in the Patent Office, whose salary, and the cost of purchasing and distributing seeds, etc. have been borne by the Patent Fund.

Some objected to an agricultural bureau on constitutional grounds or through fear that it would become subservient to political purposes. Therefore the Commissioner proposed the establishment in the Smithsonian Institution of

a department of agricultural, and one also of mechanical, science, with suitable appropriations, to aid in working out *the great practical problems of the day.* * * * To it might be referred the analysis of ores, soils, fertilizers, and vegetable products, together with propositions for the increase of speed in vehicles for traversing land and water, the application of electricity and the gases as motive agents, the extension of known materials to new manufactures, the evolution of new principles and processes, and, in a word, for everything calculated to meet the progressive demands of agriculture and the arts.

In 1852 Congress gave special authority for the purchase of seeds, and in 1854 included cuttings.

On November 9, 1852, Silas Henry Hodges (*260*) (1804–75), became Commissioner of Patents and held this office until March 25, 1853. He was a native of Vermont and a graduate of Middlebury College. He was a lawyer and for a time a clergyman, and served as chief examiner in the Patent Office from 1861 to 1875. The re-

port of that officer for 1852 was prepared under his direction. It contained articles on American pomology, by Henry F. French; the potato, by C. E. Goodrich; southern agricultural exhaustion and its remedy, by Edmund Ruffin; and the agricultural value of phosphate of lime, by Joseph Harris. In an article on the Progress of Agriculture in the United States (*119*) Daniel Lee says that—

the phenomena of tillage and husbandry cannot be successfully investigated by common farmers with their present advantages, and therefore they need institutions designed expressly to develop new truths in agriculture. [Congress] should establish an industrial university near the federal metropolis, partaking of the character of a normal school, for the thorough education of professors of the applied sciences, who are now needed in state institutions as teachers. Agricultural and mechanical schools of a high order would multiply rapidly if there existed the right sort of professors to serve the public by the skilful union of mental culture and physical labor.

The report also contains an article by Dr. Lee on American Agricultural Literature (*120*).

In 1853 Charles Mason (1804–82) became Commissioner of Patents. He was born at Pompey, N. Y., was a graduate of West Point Military Academy, and a lawyer. For some time he was a contributor to the New York Evening Post and for 2 years acted as its editor. Having moved to Burlington, Iowa, where he purchased a large tract of land, he became chief justice of Iowa Territory in 1838.

From June 1853 to 1860 the Agricultural Division of the Patent Office was in charge of Daniel Jay Browne, son of a New Hampshire farmer. He had had practical experience in farming in several places in New England; as a naturalist and student of agriculture had traveled extensively in the eastern United States, West Indies, South America, and Europe; and as a civil engineer had been connected with railroads and other enterprises. For a time he had also edited The Naturalist and the American Agriculturist. In 1854 and 1855 he visited, for the Patent Office, agricultural establishments in several European countries, giving special attention to seed and plant introduction. He was the author of a number of works, including Sylva Americana, Letters from the Canary Islands, Treatise on Maize, and American Bird Fancier. The character of the agricultural portion of the report of the Patent Office was changed so as to include chiefly brief historical statements and letters from various sources regarding domestic animals, fertilizers, improvement of land, bread crops, textile and forage crops, fruits, and wine. There was also an article of over 100 pages on the "agricultural climatology of the United States compared with that of other parts of the globe", by Lorin Blodget, of the Smithsonian Institution.

The report for 1854 followed for the most part the plan adopted in 1853. The Commissioner, however, in an introductory chapter emphasized the importance of the "introduction and naturalization of new and useful vegetable products, hitherto unknown in the United States." He justified the small packages in which the seeds of such plants were distributed, pointing out that the object of distributing them was to induce many persons to make experiments with them and reproduce them in larger quantities. He described a considerable number of species recently introduced from foreign countries. Climatology was treated through compilations of articles by J. C. Gray, D. J. Browne, and Joseph Lovering, of Harvard University. This

report also contained the first entomological contribution by Townend Glover (*250*, *251*), who had been appointed June 14, 1854, "for collecting statistics and other information on seeds, fruits and insects in the United States", and who had spent the summer months in South Carolina, studying insects affecting cotton and grapes. His article treated of these insects and also those attacking wheat, as well as the plum curculio, codling moth, peach borer, and some beneficial insects. The growing interest in the agricultural work of the Patent Office was shown by the fact that Congress authorized the printing of 210,000 copies of this report.

Commissioner Mason's report for 1855 contained a statement regarding his unsuccessful attempt to get the States to collect agricultural statistics annually and furnish the Patent Office with summaries for publication. A small appropriation for the collection of meteorological data relating to agriculture was being used in conjunction with the Smithsonian Institution in the hope that it would lead to more permanent work of this kind. A beginning in chemical investigations had been made by employing a chemist to analyze certain portions of the corn and cotton plants. Entomological studies had been continued, and measures had been begun "to test the value and relative usefulness of the various grasses to be found in the country." Glover made an extended report embodying his studies on Insects Frequenting the Cotton Plant, illustrated with numerous engravings of insects made from his own drawings.

The report also contained a short article on Insects Injurious and Beneficial to the Orange Tree, and an account of accidents and diseases of the cotton plant. Charles T. Jackson, of Boston, contributed analyses of corncobs and an article on chemical researches on cottonseed, with special reference to its use for oil. Under the head of climatology were articles on The Cotton Districts of the World, Considered with Reference to Their Climates, and Protection against the Dangers of Lightning, by Professor Lovering; Meteorology in Its Connection with Agriculture, by Secretary Joseph Henry, of the Smithsonian Institution; and meteorological data from different parts of the United States.

The report for 1856 gave an account of the special efforts being made to secure the wide introduction of sorghum seed, known as Chinese sugarcane, in the hope that this plant would provide the sugar, or at least the sirup, needed for domestic consumption. To aid the Louisiana sugarcane growers a ship was sent to South America and brought back a full cargo of sugarcane and some other plants for trial in the Southern States. The Commissioner deplored the fact that sufficient funds had not been appropriated to continue without interruption chemical, botanical, and entomological investigations. A special plea was made for experiments with grasses, as a basis for soil and livestock improvement. Many farmers would cooperate in this work if a competent leader was provided, he asserted. The Commissioner was opposed to the establishment of experimental farms in different parts of the country. "Such a course might be pursued under some governments, but would not be tolerated here. One single, sensible, well-informed, experimental agriculturist might accomplish this entire result" by visiting the several States and conferring with those most interested in agricultural prog-

ress. He proposed an appropriation of $6,000 for the appointment of three field agents to undertake this work.

Among the articles in this report which had a scientific basis were those by D. J. Browne, on the nutrition and economy of digestion of domestic animals; by Robert Kennicott, on the quadrupeds of Illinois, with 41 plates; by Ezekiel Holmes, on birds injurious to agriculture; by C. T. Jackson, on deodorization of vaults and the conversion of night soil into manure; by D. J. Browne, on calcareous manures. Professor Henry, of the Smithsonian Institution, reported that the meteorological work carried on jointly by the institution and the Patent Office had been prosecuted with increased efficiency, and he contributed an article on the physical laws and general principles of meteorology and their application to the climate of the United States.

Beginning with 1856 the language of the agricultural appropriation item was broadened to include "the collection of agricultural statistics, investigations for promoting agriculture and rural economy and the procurement and distribution of cuttings and seeds."

In 1857 Joseph Holt (1807–1894), a lawyer from Kentucky, was appointed Commissioner of Patents. In his first report of the agricultural work of the Patent Office, he emphasized the appointment of agents to visit a large region in the Southwest to procure cuttings of native grapevines "with a view to testing their adaptation to wine making and for table use", and to go to the tea districts of China to collect seeds of tea and other plants. Large amounts of the "Chinese sugarcane", i. e. sorghum, were distributed and its usefulness in stock feeding was shown. Chemists were being employed to determine the practicability of making sugar from sorghum, and chemical studies on the cotton plant and its soils and the nutritive value of various products were being continued.

Dr. Jackson reported analyses of corn, Chinese yams, potatoes, chufa, cotton plants, cotton soils, and Chinese and African sorghums. J. L. Smith, of Louisville, Ky., also reported results of his studies on the sugar-bearing capacity of Chinese sorghum. Glover gave a short account of his investigations on the insects and diseases affecting the cotton plant. Kennicott continued his account of the quadrupeds of Illinois. Professor Henry contributed a long article on the general principles of science applicable to meteorology, together with a considerable summary of observations made in different parts of the country. Commissioner Holt pointed out that more than 300 meteorological observers had been furnished with instruments and were cooperating with the Smithsonian Institution. Browne contributed an historical article on the Progress and Public Encouragement of Agriculture in Russia, Prussia and the United States, Including the Movement for Agricultural Education. That year the Patent Office had specific authority to "collect and report information in relation to the consumption of cotton in the various countries of the world."

In 1858 preparation was made for a propagating garden on five acres of land between Missouri Avenue and Four and a Half and Sixth Streets in Washington. This was tile drained and a hothouse was erected. Primarily it was intended to grow there the tea seeds from China and cuttings of grapevines collected in the United

States. Dr. Jackson contributed analyses of tobacco soils and plants from Maryland and Massachusetts. Glover reported on insects injurious to cotton plants and orange trees in Florida. Kennicott continued accounts of quadrupeds in Illinois. Professor Henry wrote again on the principles of meteorology. Browne summarized the information obtained regarding the history and status of agricultural societies in the United States. In all, 912 societies were listed, of which 799 were designated as agricultural, 43 horticultural, and 70 agricultural and mechanical.

On January 3, 1859, on the invitation of the Commissioner of Patents, citizens interested in agriculture, from most of the States and Territories, met at Washington and organized as an "Advisory Board of Agriculture of the Patent Office." This meeting lasted 8 days and resulted in an indorsement of the agricultural work of the office, a plea for increased funds for this work, an expression of great benefits being derived from the introduction of plants by the Government, and a desire that Congress should encourage "scientific and practical education in agriculture, in the establishment of colleges and schools." This group also revised the questionnaire used by the office for getting information from farmers and made it include 1,710 questions, classified according to different kinds of crops and animals.

The activities of the advisory board led to criticism in Congress of the action of the Commissioner of Patents in calling the convention at which the board was organized. A resolution was passed in the House of Representatives, calling on the Commissioner to explain this matter. Partly as a result of this agitation, the appropriation for the agricultural work of the Patent Office in 1859 was decreased, and it was provided that—

no part of this appropriation shall be used or expended in defraying the expenses of any body of men or delegates assembled in Washington or elsewhere as an agricultural congress, or advisory board on agriculture, convened under the orders of the Secretary of the Interior, or any other person under any name or for any pretended object whatever.

Commissioner Holt resigned, and William Darius Bishop (*226*) was appointed to succeed him May 23, 1859, holding office until January 1860. He was born in New Jersey in 1827, graduated at Yale College in 1849, and studied law. After practicing law a short time he was associated with his father in building railroads in Connecticut, New York, and Wisconsin. From 1867 to 1879 he was president of the New York, New Haven & Hartford Railroad. He was a Member of Congress from Connecticut from 1857 to 1859 and served as chairman of the Committee on Manufactures. Owing to the reduced appropriation in 1859 and the necessity of caring for the foreign seeds and plants and the grape cuttings which had been obtained at considerable expense, no expenditures were made for the usual varieties of garden and field seeds. In fact the Commissioner advised Congress not to make further appropriations for seeds grown in this country.

In the propagating houses on the land set apart for this purpose, the office grew for distribution over 30,000 tea plants, 12,000 foreign and domestic grapevines, 900 pomegranate cuttings, and various foreign, medicinal and ornamental plants. Dr. Jackson reported on

his studies of the saccharine and acid contents of native American grapes in relation to wine making, and Thomas Antisell, of Georgetown College, on the tartaric acid in cultivated grapes. J. F. Weber, of Washington, D. C., gave an account of his field studies of the native grapes of Pennsylvania, New Jersey, New York, and New England, and discussed grape growing and wine making. Thomas G. Clemson wrote on fertilizers. Joseph Henry contributed an article on atmospheric electricity. There is also an historical sketch of the United States Agricultural Society.

Congress apparently felt that relatively too much attention was being given to tea and grapes and therefore in the appropriation act of 1860 provided that "in the selection of cuttings and seeds for distribution due regard shall be had to the purpose of general cultivation and the encouragement of the agricultural and rural interests of all parts of the United States."

The Patent Office Report on Agriculture for 1860 was transmitted to Congress by S. T. Shugert as Acting Commissioner. This report was prepared under the direction of Thomas G. Clemson (*238*) (July 1, 1807–Apr. 6, 1888) as "Superintendent of Agricultural Affairs of the United States." He was a native of Philadelphia, had studied the sciences, particularly chemistry, mineralogy, and geology, and was a consulting mining engineer and chemist. He had also managed farms in South Carolina and Maryland. He was greatly interested in the application of science to agriculture and promoted the establishment of the Maryland Agricultural College. From 1844 to 1850 he had been Minister to Belgium. As a son-in-law of John C. Calhoun he came into possession of the Calhoun homestead, which he later gave to South Carolina to be the site of Clemson Agricultural College.

In 1860 the personnel of the Agricultural Division of the Patent Office included a Superintendent, four clerks (including translators and writers), a curator or gardener, and assistants. The 1859 appropriation for seeds had been expended for tea seeds and the construction of houses for the propagation of tea plants.

The report for 1860 urged closer and more active cooperation of the State and county agricultural societies, with special reference to the collection of agricultural statistics. Chemical and entomological investigations were strongly advocated, as well as studies of irrigation and the stocking of rivers with fish. The need of a chemical laboratory for general governmental purposes, as well as agricultural investigations, was referred to. The question of the separation of agricultural work from the Patent Office was raised. This report consisted largely of a series of essays on fertilizers, irrigation, pleuropneumonia in cattle, bee culture, insects injurious to vegetation, grape culture and wine making, forest trees of North America, tea, and agriculture in England and China.

The Patent Office report for 1861 was prepared under the direction of David P. Holloway (*261*) (1809–83), who became Commissioner March 28, 1861, and held that office until August 17, 1865. He was a native of Ohio but spent much of his life in Indiana, where he became a printer and journalist. He served in both houses of the Indiana Legislature and in 1855 was elected Member of Congress, where he became chairman of the Committee on Agriculture. The

1861 report on agriculture consisted mainly of a series of essays, including an elaborate article on The History, Industry, and Commerce of Flax, by D. J. Browne, who had been sent to Europe to investigate this subject. That year 2,474,380 parcels of garden and flower seeds and about 1,000 bushels of European wheat were distributed. Commissioner Holloway proposed the establishment of a department of productive arts or industry, with bureaus of agriculture, manufactures, and commerce. In the spring of 1861 Isaac Newton, of Pennsylvania (p. 41), was appointed Superintendent of the Agricultural Division of the Patent Office as successor to Clemson. He was serving in that capacity when the Department of Agriculture was established in 1862.

During the period from 1839 to 1862, in which the Patent Office had been the Federal agency for the promotion of agriculture, it had done little in the way of original investigations but had confined its activities very largely to the collection and dissemination of seeds and plants, mainly from foreign sources, and to the publication of a considerable amount of more or less useful information on agricultural subjects. While authorized to collect agricultural statistics it had not devised any system for doing this regularly and had indeed given up the attempt.

In 1839 Congress had appropriated $1,000 for agricultural work, but made no funds available for this purpose in 1840, 1841, or 1843. Thereafter the appropriation was resumed and the amount gradually increased to $5,000 in 1850 and to $10,000 in 1854. Up to that time the money had been taken out of the Patent Office fund, but in 1855 reimbursement was made to the extent of $40,078.78. After that the agricultural appropriation was paid directly from the Treasury. Between 1856 and 1862 the appropriation varied from $30,000 to $75,000.

MOVEMENT FOR A UNITED STATES DEPARTMENT OF AGRICULTURE

During the session of the Constitutional Convention in 1787 Gouverneur Morris, of New York, presented a plan for a Council of State, including a Secretary of Domestic Affairs, who among other things would attend to "the state of agriculture and manufactures." Charles Pinckney, of South Carolina, submitted to the convention "Observations on the Plan of Government", in which he referred to the need of a home department.

In Congress in 1789 John Vining, of Delaware, a member of the House of Representatives, proposed a domestic department. Finally the Department of State was established to deal with both foreign and domestic affairs. Therefore, Jefferson in 1790 divided his budget for this Department between a home office and a foreign office. When President Madison's message of April 20, 1812, suggested the need of additional Federal offices, Adam Seybert, of Pennsylvania, chairman of the Committee on Patents, advocated a home department. On December 3, 1816, Madison made a definite proposal to Congress for an additional department, based on a plan devised by Cabinet officers for a home department to include business relating to (1) territorial

governments, (2) national highways and canals, (3) the general post office, (4) the patent office, and (5) the Indian office.

A bill to establish such a department, which was introduced in both Houses of Congress in January 1817, failed of passage. On April 24, 1824, A. B. Woodward, in the National Journal of the District of Columbia, wrote on the necessity and importance of a Department of Domestic Affairs having eight commissioners. In the House of Representatives, March 3, 1825, a resolution was offered for a home department to promote agriculture, manufactures, etc. Presidents John Quincy Adams, Jackson, and Polk called the attention of Congress to the growing need of redistributing the duties of the Federal departments. This was greatly emphasized by the spread of population involving the creation of new States and by the land problems growing out of the Mexican War. Finally, on December 9, 1848, Robert J. Walker, Secretary of the Treasury, made a strong plea for a Secretary of the Interior to take charge of the Land Office, Indian Affairs, Patent Office, and Pension Office. He drew up a bill creating a Department of the Interior, which, with amendments, became a law March 3, 1849. The title of the act carried the designation Home Department, but in the body of the act it is called the Department of the Interior. The Patent Office, with its Agricultural Division, then became a part of this new department.

Meanwhile many proponents of agricultural promotion by the Federal Government were not satisfied to have such matters dealt with by the Patent Office and were suggesting a separate agricultural organization.

On May 8, 1882, speaking in the House of Representatives on a bill to elevate the Department of Agriculture to Cabinet rank, Congressman Aiken, of South Carolina, referred to a petition presented to Congress in 1838 by citizens of Kentucky, asking establishment of a "Department of Agriculture and Mechanics", whose head was to sit in the Cabinet. This Department was, through school teachers, to collect information about agriculture, manufactures, the weather, the state of education, and the study of insects, and to give premiums for discoveries and tests of implements. It was also to collect practical agricultural and mechanical information through the diplomatic service and disseminate this information among teachers and through them to the pupils. It was to purchase and distribute rare and valuable seeds from foreign countries.

On January 10, 1840, Joseph L. Smith and 20 others petitioned Congress "that the Committee on Agriculture be instructed to make an annual report on the agricultural interests of the Union."

This was followed on February 3, 1840, by a petition of Smith and 95 others for "the establishment of a department of the Government, to be called the Department of Agriculture and Education" (*193*).

In an article on Agriculture of Louisiana in DeBow's Commercial Review, in May 1847, R. L. Allen, of New Orleans, said that "a national board of agriculture, comprising great intelligence, sagacity, and judgment, which should have the whole subject of American production, agriculture, manufactures, and commerce before it, could do more to indicate the true policy for each section to pursue, than can be acquired in any other way."

President Zachary Taylor, also from Louisiana, in his message to Congress on December 4, 1849, advocated further Federal aid to agriculture, as follows:

> No direct aid has been given by the General Government to the improvement of agriculture except by the expenditure of small sums for the collection and publication of agricultural statistics and for some chemical analyses, which have been thus far paid for out of the patent fund. This aid is, in my opinion, wholly inadequate. To give to this leading branch of American industry the encouragement which it merits, I respectfully recommend the establishment of an agricultural bureau, to be connected with the Department of the Interior. To elevate the social condition of the agriculturist, to increase his prosperity, and to extend his means of usefulness to his country, by multiplying his sources of information, should be the study of every statesman and a primary object with every legislator (*149, p. 18*).

His action in this matter undoubtedly came out of the increased interest in agricultural affairs which in part had grown out of the discussions resulting in the creation of the Department of the Interior. Evidence of this interest was very soon shown in the action of the legislatures of Alabama, Michigan, New Hampshire, Pennsylvania, Rhode Island, Tennessee, and Vermont.

On July 31, 1850, the majority of the Committee on Agriculture of the House of Representatives asked to be discharged from the consideration of "resolutions from several state legislatures and of agricultural societies on the establishment of an agricultural bureau in the Department of the Interior." A minority report signed by four members of the committee favored such a bureau, and presented a bill for its establishment with a commissioner of agriculture at its head at a salary of $2,500. This bureau was to collect and diffuse agricultural statistics and information; to advance the science of agriculture; to procure from the several States and other parts of the world, and to distribute, the best varieties of seeds and cuttings; to establish and operate a chemical laboratory; to make analyses of parts of plants, marls, and fertilizers; and to report to Congress on experiments. Provision was made for a chemist at $2,000, a chief clerk, and a messenger. The total appropriation was to be $15,000.

President Fillmore in three messages favored an agricultural bureau. In his first message, December 2, 1850, he made the following statement:

> More than three-fourths of our population are engaged in the cultivation of the soil. The commercial, manufacturing, and navigating interests are all to a great extent dependent on the agricultural. It is therefore the most important interest of the nation, and has a just claim to the fostering care and protection of the Government so far as they can be extended consistently with the provisions of the Constitution. As this can not be done by the ordinary modes of legislation, I respectfully recommend the establishment of an agricultural bureau, to be charged with the duty of giving to this leading branch of American industry the encouragement which it so well deserves. In view of the immense mineral resources of our country, provision should also be made for the employment of a competent mineralogist and chemist, who should be required, under the direction of the head of the bureau, to collect specimens of the various minerals of our country, and to ascertain by careful analysis their respective elements and properties and their adaptation to useful purposes. He should also be required to examine and report upon the qualities of different soils and the manures best calculated to improve their productiveness. By publishing the results of such experiments, with suitable explanations, and by the collection and distribution of rare seeds and plants, with instructions as to the best system of cultivation, much may be done to promote this great national interest (*149, p. 85*).

The following year he strongly urged Congress to do something definite in this matter because—

> An agricultural bureau, charged with the duty of collecting and disseminating correct information as to the best modes of cultivation and of the most effectual means of preserving and restoring the fertility of the soil and of procuring and distributing seeds and plants and other vegetable productions, with instructions in regard to the soil, climate, and treatment best adapted to their growth, could not fail to be, in the language of Washington in his last annual message to Congress, a "very cheap instrument of immense national benefit" (*149, p. 128*).

In 1852 he again recommended the establishment of such a bureau.

At this time the growing interest in agricultural affairs led many influential men in different parts of the country, including prominent leaders in National and State politics, to believe that something more definite and important should be done nationally for the promotion of agriculture.

In an effort to give leadership to the movement in this direction, on January 14, 1851, the Massachusetts Board of Agriculture requested its president, Marshall P. Wilder, to correspond with State and other agricultural societies as to the expediency of holding a national agricultural convention. This resulted in a meeting at Washington, June 14, 1852, at which the United States Agricultural Society (*22*) was formed, with Wilder as president. This society at first attempted to constitute within itself a board of agriculture, comprising three members from each State and Territory and the District of Columbia.

> It shall be the duty of this Board to watch the interests of agriculture as they are or may be affected by the legislation of the country; to make such reports, memorials and recommendations, as may advance the cause of agriculture, promote and diffuse agricultural knowledge; to examine, and when necessary, report upon the practicability of establishing agricultural schools, colleges, and model farms; to set forth the advantages of agricultural and geological surveys, and to show the importance of the application of science to agriculture; to represent through their reports the relation of American agriculture to that of foreign countries, and endeavor to obtain information from such countries; to point out the advantage of introducing any new staples, seeds and plants, and obtain, so far as practicable, annual statistical returns of the condition of agriculture throughout the different States; all which information shall be published by the Society, and form part of its transactions (*186, p. 11*).

It seems probable that Wilder's plan for this board was an effort on his part to repeat on a national scale what he had done in Massachusetts, where, under his leadership, a voluntary board of agriculture had functioned for a time in preparation for a permanent State board which was created by the legislature. It proved impracticable to constitute a voluntary national board but in some respects the society itself acted in that capacity.

At its first session this society entered into a long discussion as to whether it should ask Congress to establish a department of agriculture. The way for this had been prepared by the action of the Maryland State Agricultural Society, which, on February 4, 1852, under the leadership of its president, Charles B. Calvert, had adopted a resolution favoring the establishment of a department of agriculture with a Cabinet officer at its head. The society's committee on business, of which C. P. Holcomb, of Delaware, was chairman, brought in a long report, in which it—

argued for the propriety and necessity of protection for the agricultural interest equally with the other great interests of the country, and had for its conclusion the recommendation of the establishment of a department or bureau of agriculture by Congress (*186, p. 13.*)

Strong opposition to this proposal immediately appeared under the leadership of Senator Stephen A. Douglas, of Illinois, and though Holcomb stoutly supported the report and was aided by others, including Calvert, the society at this session simply resolved to "respectfully request Congress to take action upon the subject of agriculture, and afford such efficient aid as in their wisdom shall be best calculated to advance the great interests of that branch of industry" (*186, p. 20*).

At the first annual meeting of the society, February 2, 1853, a resolution offered by Calvert, "that Congress be memorialized to establish a Department of the Government, to be called the Department of Agriculture" with a Cabinet officer at its head, was adopted unanimously. At the meeting in 1854 a bill, then before a committee of Congress, creating an agricultural bureau, was read. Whereupon Calvert said that the society had asked for a department with a secretary, and after debate this action was reaffirmed. In 1855 Calvert, believing that only general action on a political basis by the farmers would induce Congress to make definite provision for an agricultural branch of the Federal Government, offered a resolution favoring a convention of "agriculturists of the whole country to determine for themselves what legislation is necessary for their protection." This resolution was adopted. At this session the thanks of the society were given to Senator Jackson Morton, of Florida, "for his able report upon the establishment of an Agricultural Department."

At the banquet held in connection with the society's exhibition at Boston, Mass., in October 1855, B. B. French, of Washington, D. C., said that the farmers ought to combine to elect a Congress favorable to the establishment of a Department of Agriculture. And when this was done, "the head of it should be elected by the farmers of the country" (*70, p. 179*).

At the meeting in January 1856, Calvert said that—

when a cabinet minister represents agriculture, the farmer will be appreciated by the Government, and proper steps will be taken to advance his noble calling by all the means possible; but until such a platform is formed and such a representative takes his seat in the Cabinet, the hope the farmer cherishes that the Government will regard agriculture as its chief bulwark and cherish its advance accordingly is fallacious (*112, p. 67*).

In 1857 Wilder deplored the fact that Congress had not established "a separate department of the Cabinet for Agriculture in our national Government" (*205, p. 24*). The society then resolved to "appoint a Committee of five, to memorialize Congress, asking in the name of the Farmers of the Republic the organization of a Department of Agriculture, with a Secretary at its head entitled to a seat and a voice in the Cabinet" (*141, p. 66*). The committee consisted of W. W. Corcoran, of Washington, D. C.; G. W. P. Custis; C. B. Calvert; B. B. French; and D. J. Browne. The introduction in 1857 of Congressman Morrill's bill for a land grant to the States for industrial colleges and the widespread interest in

this measure in Congress and in the States interfered with the work of the society's committee.

In his presidential address at the annual meeting of the society in 1858 Wilder, after referring to the financial panic "unparalleled in the history of our country" (*206*, *p. 9*), and to the importance of abundant harvests "for the speedy restoration of individual and and national prosperity", said—

How important then that Government should encourage and protect the American farmer by wise legislation, and by every means in its power. We rejoice therefore in the recent presentation of this subject to Congress by the Hon[orable] Mr. Morrill of Vermont—in the increased patronage bestowed by the Government on the Agricultural Department of the Patent Office, especially in the laudable exertions of that department to collate and diffuse valuable information by its greatly improved Annual Reports, and to distribute the most desirable seeds in all parts of the country. We rejoice in these indications of progress, and in every approximation towards a result which we believe to be only a question of time—the establishment of a special Agricultural Department at the seat of Government with a Cabinet officer at its head (*206, p. 10*).

In 1859 Calvert, who had become chairman of the committee, and was at this time also president of the board of trustees of the Maryland Agricultural College, stated that it had made no progress and that "agitation of the subject might endanger the success of the Morrill Land Bill" (*142*, *p. 18*). After discussion, the society then proceeded to consider agricultural education and in the end reaffirmed its recommendation of aid by Congress to schools and colleges in the States "dedicated to practical instruction in the principles and processes of agriculture and the mechanic arts" (*142*, *p. 28*).

At the meeting in 1860 Calvert referred to a report made to the Committee on Agriculture of the House of Representatives by the "Advisory Board of Agriculture" formed at the Washington meeting called by the Commissioner of Patents. This report, which recommended the creation of a department of agriculture with a Cabinet officer at its head, had not been published. The society at that time recommended the immediate creation of a separate agricultural bureau in the Department of the Interior, as had been advocated by its Secretary, and appointed a committee, of which Calvert was chairman, to consider—

the establishment of an Agricultural Department with a cabinet minister at its head and report to the Executive Committee at as early a day as possible, some suitable plan for bringing the subject properly before the Congress of the United States.

Joseph C. G. Kennedy, superintendent of the Census Bureau, referred to the great influence of the society in bringing about more substantial recognition of agriculture by the Federal Government and expressed his belief that ultimately there would be "a department devoted principally to the interests of agriculture." That year Congressman Carey, of Ohio, in the House of Representatives, tried to have the Committee on Agriculture instructed to report a bill for the organization of an agricultural division of the Department of the Interior, but objection was made.

The coming of the Civil War materially weakened the status and influence of the society, but it continued to use such influence as

it had in favor of a department of agriculture. In his annual report on November 30, 1861, Caleb B. Smith, Secretary of the Interior, recommended "the establishment of a Bureau of Agriculture, the need whereof is not only realized by the heads of departments, but is felt by every intelligent legislator." President Lincoln accepted this suggestion and in his message to Congress, December 3, 1861, recommended the creation of an "agricultural and statistical bureau."

On January 7, 1862, a bill (*122*) for the establishment of an Agricultural and Statistical Bureau was introduced in the House of Representatives by Owen Lovejoy of Illinois, chairman of the Committee on Agriculture. Two days later W. B. Hubbard, in his presidential address at the meeting of the United States Agricultural Society, urged the farmers not to cease petitioning Congress "until a Secretary of Agriculture, representing your combined interests, has a potential voice in the Cabinet of your President of the United States." The bill was referred to the Committee on Agriculture, of which Calvert was at that time a member. His influence, backed by that of the society, was undoubtedly shown in the bill (H. R. 269) reported to the House by Mr. Lovejoy, for the committee, on February 11, 1862. This was a compromise measure which created a separate department but put at its head a commissioner to be appointed by the President.

The bill was considered in the House for a short time on February 17. Amendments were adopted reducing the commissioner's salary from $5,000 to $3,000 and restricting the number of employees to such as "Congress may from time to time provide." The bill was then passed by a vote of 122 yeas and 7 nays. The next day three Members, including Mr. Morrill, of Vermont, asked to be recorded as favoring this measure.

The bill was received in the Senate on February 18, 1862, and was referred to the Committee on Patents and the Patent Office. It was reported back March 20, without amendment, but on March 24 was recommitted to this committee. On March 26 a new bill (S. 249) to establish a department of agriculture was introduced by Senator Wright, of Indiana, and referred to this committee.

On April 10 the original bill was again reported, with amendments, to the Senate, and was considered there on April 17.

Senator Wright then proposed to substitute his bill, which provided that in this department there should be bureaus of "(1) Science and Practice of Agriculture, (2) Natural History Connected with Agriculture, (3) Agricultural Chemistry and (4) Agricultural Mechanics, Manufactures, Commerce, and Statistics." The bill went over until April 22, when this substitute was rejected. Then Senator Foster, of Connecticut, proposed a substitute bill which would create in the Department of the Interior a bureau of agriculture and statistics to promote the interests of agriculture, commerce, and manufactures.

On May 8, after considerable debate, the substitute bill was rejected by a tie vote. The committee's bill was then passed by a vote of 25 yeas to 13 nays. It immediately went back to the House, where the Senate amendments were accepted on May 13. It was approved by President Lincoln on May 15, 1862.

THE UNITED STATES DEPARTMENT OF AGRICULTURE, 1862–88 (*197*),

ADMINISTRATION OF COMMISSIONER ISAAC NEWTON, 1862–67

The United States Department of Agriculture was organized by Isaac Newton (*285*, *286*) (Mar. 31, 1800–June 19, 1867) (fig. 2), who was promoted July 1, 1862, from his position as chief of the agricultural section of the Patent Office to be the first Commissioner of Agriculture, holding that appointment until his death in 1867. He was born in Burlington County, N. J., and grew up on a farm, receiving only a common-school education. He settled on a farm in Delaware County, Pa., near Philadelphia, where he was a successful and progressive farmer. As a member of the State Agricultural Society he secured the passage of a resolution favoring the establishment of a United States Department of Agriculture. He was several times a delegate to the meetings of the United States Agricultural Society and brought the project to the personal attention of Presidents Harrison, Tyler, Fillmore, and Lincoln. As rapidly as war-time conditions in the National Capital permitted, he proceeded after his appointment to put the Department on a firm basis, and was much interested in promoting its experimental and scientific work.

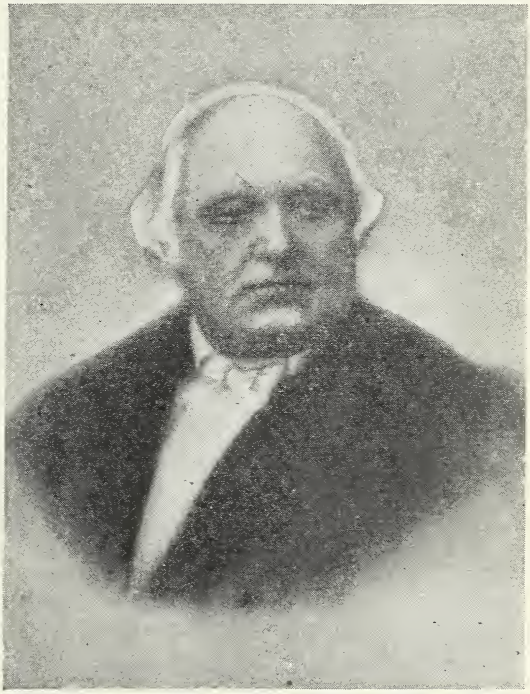

FIGURE 2.—Isaac Newton, 1800–1867. First Commissioner of Agriculture, 1862–67.

In developing the Department, Commissioner Newton kept in view the plan for a National department of agriculture which had been outlined about 20 years before by Jesse Buel as follows: (1) Collection and dissemination of statistical and other useful information relating to agriculture; (2) collecting and distributing seeds and plants for use in this and other countries; (3) answering inquiries of farmers and others on all matters relating to agriculture; (4) testing by experiment implements, cereals, seeds, and plants; (5) chemical analysis of soils, grains, fruits, plants, vegetables, and manures, and publication of results; (6) establishing professorships of botany

and entomology; (7) establishing an agricultural library and museum.

The initial appropriation for the Department was $60,000, to which was added on March 3, 1863, a deficiency appropriation of $20,000. For the fiscal year 1867 the appropriations aggregated $199,100. The Department had six rooms in the basement of the Patent Office building, which had formerly been occupied by the Agricultural Division, and gradually acquired possession of the property of that Division, including the propagating garden at Sixth Street and Missouri Avenue NW. There was also assigned to it a tract of land, lying between Twelfth and Fourteenth Streets from B Street SW to the canal (now Constitution Avenue), which was being used by the War Department as a yard for army animals. This tract, now forming the Department grounds, did not come into its possession until April 1865, when it was made an experiment farm. The Commissioner's son, Isaac Newton, Jr., was put in charge of this farm but was succeeded in September 1865 by George Reid.

Tests were made that summer of new and promising varieties of corn, wheat, rye, oats, barley, rice, sorghum, peas, beans, grasses, clover, cabbage, lettuce, onions, tomatoes, potatoes, and melons. Seventy-seven varieties of potatoes were tried. A large quantity of seed was saved from the farm and distributed during the winter and spring.

Seeds of cereals, cotton, tobacco, and vegetables were procured from domestic and foreign sources for distribution. In 1863 about 1,200,000 packages of seed and 25,750 bulbs, cuttings, and vines were distributed with the aid of Congressmen and agricultural societies.

The Civil War had greatly reduced the supply of cotton in the South, and efforts were made to grow this crop further north. Substitutes for it were also sought. An act of Congress of February 25, 1863, appropriated $20,000 "for investigations to test the practicability of cultivating and preparing flax and hemp as substitutes for cotton." A commission of three men was appointed to make this investigation and to study the production and manufacture of flax, hemp, and other fibers. Manufacturers made efforts to improve the machines and processes for making fabrics from flax which would take the place of cotton goods, but were only partially successful, and the close of the war put an end to work in this direction. The report of the commission was submitted to Congress February 28, 1865 (*194*).

The cutting off of cane sugar and molasses from the South also gave impetus to the introduction of sorghum from China, and created interest in experiments for the production of sugar from beets, which had been so successful in Europe. Under Commissioner Newton's administration the Department began the investigation of both sorghum and beets as sugar-producing plants.

Soon after becoming Commissioner, Newton called to Washington William Saunders (*302*) (1822–1900), a leading horticulturist and landscape gardener, for consultation in laying out the Department grounds and planning its horticultural work. Saunders was appointed botanist and superintendent of the propagating garden and served in the Department 38 years. He was born at St. Andrews, Scotland, of a family of gardeners. His early education included botany, horticulture, and landscape gardening, and this was followed

by a course in horticulture at the University of Edinburg, with several years in practical gardening. He came to the United States in 1848 and engaged in gardening on an estate at New Haven, Conn. Immediately he began to contribute articles to Hovey's Magazine of Horticulture. Later he was for many years assistant editor of The Horticulturist, and wrote much for other journals. In 1854 he entered into partnership with Thomas Meehan at Germantown, Pa., and the firm built up a large business in horticulture and landscape gardening. He was broadly interested in agriculture and country life. In 1855 he published suggestions for a farm organization with features like those of the Grange. In 1867 he was one of the founders of the Grange and was the first master of the National Grange.

Under Saunders' direction the Department's propagating garden was used during Commissioner Newton's administration for growing grapes, pears, strawberries, gooseberries, grain, and vegetables. A glasshouse for orchard fruits was erected, and in 1865 a greenhouse with a section for tropical plants was built.

On August 21, 1862, Charles Mayer Wetherill (*323*) (Nov. 4, 1825–Mar. 5, 1871), was appointed Department chemist and served until October 1863. He was born at Philadelphia, graduated at the University of Pennsylvania in 1845, studied under Pélouze at the College de France at Paris and under Liebig at the University of Giessen where he received the Ph. D. degree in 1848, and was given the honorary degree of M. D. by the New York Medical College in 1853. He was a member of the American Philosophical Society and other scientific bodies. His works include some 40 papers in the Journal of the Franklin Institute, American Journal of Science, etc. Among them was an important Treatise on the Manufacture of Vinegar. His first report as chemist of the Department, submitted January 1, 1863, contained analyses of grape juice, sorghum, beets, and imphee, results of examinations of various sugars and sirups, and an article on the chemistry of sugar manufacture.

Henri Erni was appointed chemist in 1864 and served 2 years. He came to this country from Switzerland, where in 1847 he had investigated the cause of fermentation at the Chemical Laboratory in Zurich, with the conclusion that "alcoholic fermentation is caused by the development of fungi" (*62*). In 1850 he was assistant chemist in the laboratory of the Yale Scientific School. Analyses made by him are recorded in the American Journal of Science for that year.

When the American Association for the Advancement of Science met at New Haven in August 1850, Erni was elected a member, along with S. W. Johnson. From Yale he went to the University of Vermont as professor of natural science and then to Shelby Medical College at Nashville, Tenn., as professor of medical chemistry and jurisprudence. While chemist in the Department of Agriculture he wrote anonymously for the Sunday Morning Chronicle of Washington a series of articles on Coal Oil and Petroleum; Their Origin, History, Geology, and Chemistry, with a View of Their Importance in Their Bearing upon National Industry (*63*). These papers were assembled in a monograph published in Philadelphia in 1865. He also wrote a translation of F. von Kobell's Mineralogy Simplified, and added to it material on blowpipe analysis, etc. After leaving the Department of Agriculture he was for a time an examiner in the Patent Office.

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In the Department analyses were made of soils, guano, sorghum, imphee, sugar beets, wines, etc., and there were some experiments on vinous, acetic, and butyric acid fermentations, theories of the origin of mold, methods of detecting artificial coloring matters in wines, etc. Considerable time was spent in making analyses of miscellaneous substances, such as ores, rocks, etc., sent in by private parties or by other departments. Such work grew materially in succeeding years.

Thomas Antisell (*217*) (Jan. 16, 1817–June 14, 1893) began work as Department chemist in July 1866 and served until 1871. He was born in Dublin, Ireland, and was educated in Ireland, England, and Germany, specializing in chemistry. He began the practice of medicine in Dublin and lectured on chemistry and botany at the Dublin School of Medicine. In 1844 he wrote "on the application of light polarized circularly to the investigation of chemical and physiological phenomena" for the Pharmaceutical Journal of England (*10*). He came to this country in 1848. For some time before the Civil War he was an examiner in the Patent Office, in charge of the chemical division. From 1859 he was for 32 years professor of chemistry in the medical department of Georgetown College and received the degree of Ph. D. from that institution. He addressed the United States Agricultural Society in 1859 on The Relations of Physical Geography to Agriculture. In 1871 he went with Commissioner Capron as technologist of the commission appointed by the Japanese Government to promote the development of the northern islands of that empire, serving in this capacity for 6 years.

Among Dr. Antisell's works were a short Manual of Agricultural Chemistry and a Handbook of the Useful Arts. His work in the Department of Agriculture during Commissioner Newton's administration consisted chiefly of analyses of soils, peat, muck, marls, grapes, wines, maple sap, sorghum, beets, and gold and silver ores and other minerals.

Systematic work in entomology was begun in the Department in 1863 with the appointment of Townend Glover, who continued in that office until 1878. His reports during Commissioner Newton's administration largely consisted of original and compiled notes on numerous insects, arranged according to the natural orders. In 1865 he attended an entomological convention in Paris and reported on the exhibit of insects there. He brought back some silkworms to be used in connection with the efforts which were still being made to establish a silk-growing industry in this country. He also reported observations of birds useful or injurious to agriculture. A large share of his time was spent on the agricultural museum, begun in two rooms, in which was installed his collection of insects, birds, models of fruit, and herbarium. From time to time materials sent in by consuls and other persons were added. In 1867 Glover's collection was bought by the Department for $10,000.

After 1849 the Patent Office did not attempt systematic statistical work and reports. This change of policy was due to the lack of State and local organization for such work. This lack had led Dr. Lee, then in charge of this work, to declare that the reports were mere guess work. There was, however, a growing demand for such information, and this demand had entered into the movement which resulted in the establishment of the Department of Agriculture.

Commissioner Newton, therefore, immediately began to make plans for regular statistical work and in the report of the Department for 1862 included statistics of agricultural production, based on the Eighth Census, and added statistics on exports from the United States.

Early in 1863 Lewis Bollman, who had been engaged in farming near Bloomington, Ind., was appointed statistician. He was born September 28, 1823, at New Boston, N. H., and was educated in common schools and academies, receiving an honorary A. M. degree from Dartmouth College in 1879. He had wide experience in teaching and in journalism. Associated with Bollman was Jacob Richards Dodge (*244*), who had already been working in the Agricultural Division of the Patent Office, had been appointed a clerk in the Department September 4, 1863, and had prepared the statistics contained in the 1862 report. In 1867 Dodge was given the title of Statistician, succeeding Bollman, and served in that capacity and as editor of the Department publications until June 30, 1879, when he became chief of the agricultural division in the Tenth Census. He returned to the Department as Statistician July 1, 1883, and continued in that position until he resigned on March 20, 1893. He died at Woburn, Mass., October 1, 1902.

Mr. Dodge's broad knowledge of agricultural conditions in this country and abroad and his wide acquaintance with influential persons in public and private life, as well as his statistical and editorial ability, great industry, and good judgment in administrative affairs, enabled him to have a large part in the development of the Department during its first 30 years. Besides doing his statistical work, he wrote for Department publications on a great variety of agricultural subjects. Among his unofficial writings are West Virginia, Its Farms and Forests, Mines and Oil-wells; and Farm and Factory.

The plan adopted for the statistical work of the Department was based on that used by Orange Judd of the American Agriculturist and resembled the one used in Prussia. Correspondents with from three to five assistants in each county sent in replies to a Department circular on the same day each month Monthly reports, beginning July 10, 1863, were issued from May to September and bimonthly reports during the other months. The data collected were on (1) annual crops, livestock, and dairy products, (2) exports of domestic produce and their value, and (3) information on general and important topics relating to agricultural production. Agents were asked to report on crops at different stages of growth, insects and diseases, amount harvested, prices, and increase or decrease of livestock.

Meteorological data furnished by the Smithsonian Institution appeared in the monthly and annual reports from 1863 to January 1872. In his report for 1863 and again in 1864 Commissioner Newton suggested that "the state of the weather at different points of the country might be daily communicated by telegraph and immediately spread over the whole country with beneficial results."

A foundation was laid for the Department Library during this administration, and it was specifically mentioned in the item of $4,000 for the library and laboratory in the appropriation act of 1864.

After much effort, Commissioner Newton, on March 2, 1867, secured an appropriation of $100,000 for a Department main building. The brick structure (fig. 3) erected with this appropriation was completed and occupied in August 1868.

After Commissioner Newton's death John W Stokes, the Chief Clerk of the Department, was Acting Commissioner until December 4, 1867.

ADMINISTRATION OF COMMISSIONER HORACE CAPRON, 1867–71

Horace Capron (*234*, *235*) (Aug. 31, 1804–Feb. 22, 1885), of Illinois, was appointed Commissioner of Agriculture November 29, 1867. He was born at Attleboro, Mass., but moved to Whitesboro, N. Y., in 1806 and lived there 17 years. From 1829 for about 20 years he was

FIGURE 3.—First main building of the Department of Agriculture, completed and occupied in 1868.

engaged in manufacturing in Maryland. His farming activities were extensive. In 1852 he traveled to northern Texas as a special commissioner to negotiate treaties with Indians, and 2 years later he moved to Illinois, where he bred Devon cattle. He became vice-president of the Illinois State Agricultural Society, and in 1859 was on the executive committee of the United States Agricultural Society and was superintendent of its fair at Chicago.

After serving 4 years as United States Commissioner of Agriculture he went to Japan as chief of a Government commission to promote the development of the northern islands of that Empire. He was accompanied by Dr. Antisell and Stuart Eldridge, librarian of the Department of Agriculture. The commission did important work for several years, and among other things Capron recommended

the appointment of President Clark of the Massachusetts Agricultural College, who, with Professor Brooks of that college, organized the Sapporo Agricultural College (now the Hokkaido Imperial University). Returning to the United States in 1875 he resumed residence in his Maryland home.

The new building, completed and occupied in 1868, gave the Department much better quarters and opened the way for reorganization and enlargement of its work. The grounds about this building were too small for an experiment farm. On the suggestion of the chief clerk, John W. Stokes, it was planned to use them for an arboretum. Work in this direction was begun under the supervision of Saunders, and an interesting collection of trees and shrubs, largely those native to North America, was gradually made. Seed distribution had grown to large proportions, and in the fiscal year 1867, out of a total appropriation of $199,100 for the Department, $115,200 was used for this purpose. This led to much criticism in and out of Congress, since many ordinary and in some cases inferior seeds were being distributed, and the imported varieties had not been subjected to experimental tests in different parts of the country and were commonly unfit for growing in the United States.

On December 9, 1867, the House of Representatives passed a resolution instructing the Commissioner of Agriculture to report to it the condition of the Department and what legislation was necessary to enable him to reorganize it and make its work commensurate with the agricultural interests of the country. To this the Commissioner made an elaborate reply on January 13, 1868. He admitted failure of the seed distribution and the experiment farm. He believed that the former should be reorganized and limited to seeds of superior quality, and that these should be sent out for experimental tests to persons who would be responsible for making such tests and reporting the results. An experiment farm of not less than 200 acres should be provided near Washington and the propagating garden should be transferred to this farm. The statistical and chemical work of the Department should be enlarged, as well as the agricultural museum and the collections in agricultural geology and entomology. The personnel of the Department should be enlarged to include a statistician, chemist, superintendent of experimental garden, botanist, superintendent of seed room, librarian, assistant chemist, assistant superintendents of gardens and of seed room, disbursing officer, 25 clerks, 3 messengers, 2 workmen, and 6 laborers.

Congress cut down the 1869 appropriation to $172,593, of which only $20,000 was for the purchase of seeds. An attempt was made to improve the distribution of seeds and plants. A system of exchanges with foreign governments, societies, and individuals was begun. Reports of tests in different parts of the country were published, as well as accounts of other farm experiments. The growing importance of the land-grant colleges led the Department to publish annual accounts of their organization and work. The propagation of exotic plants under glass was increased, and a large conservatory for this purpose was erected near the main Department building.

The importance of establishing a beet-sugar industry in this country was urged by Commissioner Capron in his first report. Experi-

ments in growing sugar beets were conducted on the Department grounds, chemical analyses of the products were made, and accounts of the sugar-beet industry in Europe and of experiments with sugar beets in Illinois and California were published.

Experiments with orchard fruits were made in the propagating garden, and illustrated accounts of different varieties grown elsewhere were published. The entomologist made observations and published notes on miscellaneous insects but gave much of his time to developing the agricultural museum, including models of fruits. The chemist made analyses of soils, marls, wines, and various crops, but the chemical work on other than agricultural materials was greatly curtailed.

In 1868 John Gamgee, of the Albert Veterinary College of London, who had investigated an outbreak of tick (Texas) fever of cattle in Illinois for the Pork Packers Association of Chicago, was employed by the Department to investigate this fever in other sections, particularly Texas and Kansas. The expenses of this investigation were paid from the funds of the Statistical Division. In reporting this the Commissioner urged Congress to create a division of veterinary surgery and renewed this recommendation in following years.

In 1869 Congress appropriated $15,000 for investigations of animal diseases. Work on tick fever was continued by Professor Gamgee, who was aided by Drs. Billings and Curtis of the Surgeon General's Office; H. W. Ravenel, a botanist of South Carolina, who studied the fungi of Texas; and J. R. Dodge, who collected statistical and historical information on the disease. Other diseases, particularly pleuropneumonia, were studied by J. J. Woodward of the Army. An elaborate, illustrated report (*28*) of the investigations was made in 1871, and miscellaneous information on various diseases of animals was published in the reports of the statistician.

A petition, signed by Francis E. Spinner, United States Treasurer; Seth Green, New York fish commissioner; and other influential men, asking the Commissioner of Agriculture to call the attention of Congress to the importance of our fisheries and the need of Federal assistance in their further development, led to the publication of a long article on Recent Progress in Fish Culture in the annual report of the Department for 1868 (*54*). This was followed by other articles on fish culture in succeeding years, and thus the foundation was laid for the United States Fish Commission, which was established in 1871.

In 1868 Joseph Henry, secretary of the Smithsonian Institution, called the attention of the Department to the large number of botanical specimens obtained in the explorations of Hayden and others in the West, the Japan Expedition, and other sources, which had accumulated at the institution but which had not been mounted and arranged properly. It was thought that a herbarium based on these collections and increased by future studies and explorations would have much scientific and practical value, would aid the introduction of foreign plants having economic value, and would promote intelligent development of agriculture in the vast regions west of the Mississippi River, which were open to settlement under the Homestead Act. An agreement was therefore reached by which the Smithsonian collections were transferred to the Department of Agriculture with

the understanding that a competent botanist would be employed to establish and maintain a herbarium.

Charles Christopher Parry (*289*) (Aug. 28, 1823–Feb. 20, 1890) was appointed Department botanist in March 1869. He was born at Admington, Gloucestershire, England, but in 1832 moved with his family to a farm in Washington County, N. Y. He graduated at Union College, Schenectady, studied medicine, and received the degree of M. D. from the New York College of Physicians and Surgeons. He began the practice of Medicine at Davenport, Iowa, in 1846, but soon abandoned this for a career as a botanist.

He had begun collecting plants near his New York home in 1842 and had come under the influence of John Torrey. In 1847 he collected in Iowa and the following year went with Owen's geological survey as far north as Lake Superior. From 1849 to 1853 he was botanist of the Mexican Boundary Commission and made extensive collections in the Southwest, as far as San Diego, Calif. During the next 12 years he collected plants privately in Iowa and among the Rocky Mountains and in 1867 went from Kansas to California with surveyors of the Pacific Railroad.

During his connection with the Department of Agriculture, Parry was principally engaged in herbarium work but found time to visit Europe and especially the Kew Gardens in England. After leaving the Department in 1871 he made extensive collections of plants in the Northwestern States and on the Pacific coast, going also into Lower California and Mexico. In 1889 he traveled in New England, New York, and Canada. He died at his home near Davenport, Iowa. He was president of the Davenport Academy of Natural Sciences from 1862 to 1875 and left to it his herbarium (*139*), which contained over 18,000 specimens, representing nearly 6,800 species. He discovered hundreds of new species and made very important contributions to the knowledge of the flora of the Western States. His writings consisted mainly of lists of plants. His collections included many grasses, forage plants, and fibers. His work for the Department was criticized as not having a sufficiently agricultural outlook, and this led to his retirement from the Government service. However, he laid the foundation for what has since become the great National Herbarium, now in the Smithsonian Institution.

ADMINISTRATION OF COMMISSIONER FREDERICK WATTS, 1871–77

Frederick Watts (*322*) (May 9, 1801–Aug. 17, 1889), of Pennsylvania, was appointed by President Grant to fill the vacancy caused by the resignation of Commissioner Capron and began service as head of the Department of Agriculture August 1, 1871. He was born at Carlisle, Pa. He was graduated at Dickinson College in 1819 and was admitted to the bar in August 1824. He became president of the Cumberland Valley Railroad in 1845. He was reporter of the Supreme Court of Pennsylvania, edited its reports from 1832 to 1845, and was president-judge of the ninth judicial district of Pennsylvania from 1849 to 1852. He gave up the practice of law in 1858 to manage his farm near Carlisle, Pa., in which he had been interested for many years. In 1856 he became the first president of the Pennsylvania Agricultural Society and held that office from 1856 to

1862. He was one of the founders of the Pennsylvania Farmers' High School (now State College) in 1857, and the first president of its board of trustees, continuing in that office until 1874. On leaving the Department in 1877 he retired to his farm.

In 1873 the lot which had long been used as a propagating garden was exchanged for about 4 acres of land on the north side of the Department grounds, which had formerly been connected with the canal occupying the site of B Street NW, then recently opened. This marshy land was utilized in growing willows and different kinds of herbaceous plants suited to wet soils. A small lake was made on this tract, in which waterlilies and other aquatic plants were grown; and rhododendrons, azaleas, and similar plants were planted on little islands in this lake.

In his report for 1871 Commissioner Watts advocated abandonment of the annual report, believing monthly reports would suffice. If the annual report was to be continued, he urged that most of the edition should be sold by the Public Printer. Congress decided not to make an appropriation for printing the reports for 1872 and 1873, but changed its policy in 1874 and provided $50,000 for printing these reports. The refusal to print reports was due to the abolishment of the franking privilege for Congress and the Government departments under the act of January 31, 1873, which went into effect July 1 of that year. This made necessary an appropriation to the Department of $52,000 for each of the fiscal years 1874, 1875, and 1876; though in the latter year only $3,428 was spent, because the franking privilege was restored for seeds and publications. The appropriation for seed distribution was raised from $45,000 in 1872 to $95,000 in 1875. For other ordinary expenses of the Department between about $150,000 and $200,000 was spent annually during the administration of Commissioner Watts. He stopped the Department's publication of the meteorological data furnished by the Smithsonian Institution and "suggested that the work be turned over to the Signal Service of the Army." In response, Congress, on June 10, 1872, made an appropriation with which "the War Department was directed to collect and publish meteorological information for the benefit of agriculture."

The statistical work went on about as before with the aid of about 3,000 voluntary reporters, but in 1876–77 was hampered by a reduction of the appropriation from $15,000 to $10,000.

The Department had no chief chemist from July 1871 until January 11, 1872, when Ryland T. Brown (*229*) (Oct. 5, 1807–May 2, 1890) began work in that position. He was a native of Kentucky but lived principally in Ohio and Indiana, where he studied and practiced medicine. In 1830 he was graduated from the Ohio Medical College at Cincinnati. In 1854 he became State geologist of Indiana and engaged in locating coal fields. In 1856 and 1857 he was a member of the Indiana State Board of Agriculture and for many years was superintendent of its department of natural history and geology. From 1858 to 1871 he was professor of natural science in the Northwest Christian University at Indianapolis. His work for the Department of Agriculture consisted largely of analysis of fertilizers, tea plants, and miscellaneous substances.

Brown was succeeded by William McMurtrie (*275*) (Mar. 10, 1851–May 14, 1913), who had been appointed assistant chemist in 1872.

He was born near Belvidere, N. J. He graduated in 1871 with the degree of M. E. and received the Ph. D. degree from Lafayette College in 1876.

McMurtrie represented the Department of Agriculture at the Paris Exposition of 1878. This gave him an opportunity to study agricultural conditions in Europe. His report on the sugar-beet industry there laid the foundation for subsequent work on this crop in the United States. Later he was a special agent of the Department in agricultural technology and gave particular attention to sugar, wine, oil, and silk. In 1880 he reported on the sheep, wool, and wool products at an international exposition at Philadelphia. His report on the investigation of wool and the animal fibers was published in 1886 (*124*). He became chemist of the Illinois State Board of Agriculture in 1884 and in 1888 was chemist of the Illinois Experiment Station.

Under the direction of McMurtrie the Division of Chemistry of the Department of Agriculture made many analyses of soils, marls, corn, sugarcane, and southern forage plants. It also reported on the use of Paris green in agriculture, the influence on vegetation of arsenical compounds in the soil, American sumac in relation to tannic acid, the physical and chemical causes of mildew and rot, the presence or absence of the so-called peptone-forming ferment in the roots of plants, and a beginning of studies of sugar beets and Early Amber cane.

The entomologist, Townend Glover, continued to publish notes on a considerable number of different species of insects, and made special studies of grasshoppers in the West and of the Colorado potato beetle. Much of his time was spent on his duties as curator of the Department museum and in the preparation of an exhibit for the Centennial Exposition at Philadelphia.

In 1871 was begun a systematic study of diseases of plants, when Thomas Taylor (Apr. 22, 1820–Jan. 22, 1910) was appointed microscopist. He was born in Perthshire, Scotland, took a scientific course at Glasgow University, and studied art and drawing at the British School of Design. In 1851 he came to the United States, where, during the Civil War, he made experiments with projectiles. After coming to Washington he studied medicine at Georgetown University and received the M. D. degree in 1882. As was then customary, he practiced medicine outside official hours for a time. In 1897 he published the Students' Handbook of Edible and Poisonous Mushrooms. For the Department report for 1871 he wrote an illustrated article on fungoid diseases of the grapevine, the pear and peach trees, and the lilac. During the next 5 years he reported observations on pear blight, onion blight and smut, peach yellows, potato blight and rot, black knot of plums, and cranberry diseases.

On April 1, 1872, George Vasey (*317*) (Feb. 28, 1822–Mar. 4, 1893) was appointed botanist of the Department. He was born near Scarborough, England, but when 1 year old came to Oriskany, Oneida County, N. Y. He received a common-school education. Through P. D. Knieskern, a botanist, he was encouraged to continue the study of botany, and gave special attention to the *Carex* genus. After graduating at the Oneida Institute he studied medi-

cine at the Berkshire Medical Institute at Pittsfield, Mass., receiving the M. D. degree. He practiced medicine for a time, meanwhile collecting and studying plants. In 1868 he went with Powell's Colorado Expedition, bringing back many specimens. In 1869 he was associated with C. V. Riley in editing the Entomologist and Botanist at St. Louis and in 1870 became curator of the museum of the Illinois Natural History Society at Bloomington.

On coming to the Department Dr. Vasey commenced systematically to classify and enlarge the National Herbarium. For this work he was well fitted, and his patient labor resulted in making this herbarium one of the great scientific collections of plants. By exchanges with foreign institutions and distribution of duplicate specimens to colleges and other organizations throughout the United States the educational value of the herbarium was greatly enhanced.

Commissioner Watts was much interested in problems relating to forestry. With his encouragement Dr. Vasey began the collection of sections and botanical specimens of forest trees and a notable exhibit of such material was made at the Centennial Exposition. A catalog of the native and naturalized forest trees of the United States was published in the Department report for 1875, together with an article of over 100 pages on the statistics of forestry in the several States and Territories, largely based on reports from the statistical agents.

Under the act of Congress of August 16, 1876, the Commissioner was directed to spend, from the sum appropriated for the purchase of seeds, $2,000 as compensation for a man qualified to report comprehensively on forestry. Franklin B. Hough (*263*) (July 20, 1820–June 6, 1885), of Lowville, N. Y., who had made and published many statistical and historical studies and was familiar with the plants and agriculture of New York, was appointed to prepare this report, in connection with which he traveled extensively in the West. His first report (*99*), a volume of 650 pages dealing broadly with forestry matters in this country and Europe, was transmitted to Congress December 13, 1877.

Since Commissioner Watts was greatly interested in the agricultural colleges and their experimental work, he desired close relations between them and the Department of Agriculture. To promote these relations he called a convention of representatives of these colleges and the State agricultural boards and societies, which met at the Department February 15, 1872, and was an important factor in the movement which led the States to establish agricultural experiment stations, beginning with Connecticut in 1875, and which led the Federal Government to aid such stations through the Hatch Act of 1887. The Department continued to publish accounts of the progress of the land-grant colleges and the results of their experiments. The report for 1875 contained an article by W. O. Atwater, director of the Connecticut Experiment Station, on the agricultural experiment stations in Europe.

ADMINISTRATION OF COMMISSIONER WILLIAM GATES LEDUC, 1877–81

William Gates LeDuc (*272*) (Mar. 29, 1823–Oct. 30, 1917) became Commissioner of Agriculture July 1, 1877. He was born at Wilkesville, Ohio. He prepared for college at Lancaster Academy

and graduated at Kenyon College in 1848. He then studied law and was admitted to the bar in Ohio in 1850. Going that year to St. Paul, Minn., he first was a bookseller but gradually undertook law practice in land-office courts. He was active in promoting immigration to Minnesota, securing the first charter for a railroad in this Territory and organizing a company to build the first bridge across the Mississippi River. In 1856 he moved to Hastings, Minn., where he engaged in wheat growing and milling, and in land speculation.

On entering the Department Commissioner LeDuc was greatly impressed with the desirability of investigations on sugar-producing plants with a view to increasing materially the manufacture of sugar in the United States. At first, attention was centered on sugar beets and afterward some work was done on corn, pearl millet, and teosinte. But the most extensive work in this line during this administration was done with sorghum.

This work was in charge of Peter Collier (*239*) Aug. 17, 1835–June 29, 1896), who was appointed Department chemist January 22, 1878. He was born at Chittenango, N. Y., prepared for college at the Yates Polytechnic Institute, and graduated at Yale College in 1861. He then studied general and analytical chemistry and worked as an assistant in the Sheffield Scientific School, chiefly under S. W. Johnson, and received the Ph. D. degree there in 1866. From 1867 to 1877 he was professor of chemistry and mineralogy in the University of Vermont, and professor of chemistry and toxicology in the medical department of that university, receiving there the M. D. degree and becoming dean of the medical faculty. In 1871 he was elected secretary of the Vermont State Board of Agriculture, Mining, and Manufactures, and conducted the first series of farmers' institutes in that State. He was a member of the United States Scientific Commission to the Vienna International Exposition in 1873. From 1887 to 1895 he was director of the New York Agricultural Experiment Station. He died at Ann Arbor, Mich.

Dr. Collier's investigation of sorghum as a sugar-producing plant covered the agricultural, chemical, and technical phases of this subject. Many varieties of sorghum were grown at the Department and in other places; several thousand analyses of sorghum plants at different stages of growth were made; and experiments in sugar making were conducted in the laboratory and in two small mills erected on the Department grounds. Information on this plant and its use in making sirup and sugar was collected from a great variety of sources. Although many difficulties were encountered in making sugar from sorghum, and economic problems were not solved, when Dr. Collier left the Department in 1883 he was firmly convinced that in time the manufacture of sorghum sugar would be a profitable industry in the United States. Besides his official reports on this subject, he published in 1884 a comprehensive book on Sorghum, Its Culture and Manufacture Economically Considered as a Source of Sugar, Syrup, and Fodder (*31*).

Commissioner LeDuc was much interested in the promotion of tea culture in the United States. He grew and distributed thousands of tea plants, had analyses made, and in 1880, with the aid of a special appropriation of $15.000, leased a farm at Summerville, S. C., for experiments with this plant.

The botanist entered upon a long study of grasses and had the cooperation of the chemist, who made analyses of a considerable number of species. Beginning with 1878 the reports contained many illustrations of grasses.

Seed distribution was severely criticized by the Commissioner in his first annual report, and an attempt was made to limit it to "new and valuable seeds." The appropriation for the purchase of seeds was $75,000 from 1877 to 1879, but in 1880 it was $102,100. In 1877, 2,333,474 packages were sent out, together with 156,862 plants and cuttings. In 1880 the law regulating this distribution was changed, and "an equal proportion of three-quarters of seeds, plants and cuttings" had to be distributed on orders of Members of Congress.

From 1878 to 1881 J. R. Dodge was in charge of the agricultural work of the Census, and his place as statistician of the Department was taken by Charles Worthington. Besides the statistician, the Division of Statistics employed an assistant statistician and five clerks. The number of correspondents was about 4,000. Though the annual appropriation for the miscellaneous expenses of this Division was kept at $10,000 the work was somewhat increased. In 1880 statistics of farm wages and the price of farm lands were included in the report. Commissioner LeDuc that year advocated doubling the statistical force.

In June 1878 Charles Valentine Riley (*294*) (Sept. 18, 1843–Sept. 14, 1895) became entomologist of the Department. He was born in London, studied in France and Germany, and early developed much artistic skill, which later was of great advantage to him in making drawings of insects. He came to the United States in his seventeenth year and worked for 3 years on a farm in Kankakee County, Ill., spending much of his leisure time cultivating flowers and studying insects. Then he became entomological editor of The Prairie Farmer and in 1864 served 6 months as private in an Illinois regiment. His numerous contributions to various periodicals gave him world-wide reputation as an entomologist and led to his appointment in 1865 as State entomologist of Missouri. About this time he also began studies of the phylloxera, which were so highly appreciated in France that he received a gold medal from the vine growers in 1873. The Kansas State Agricultural College gave him the degree of A. M., and the University of Missouri conferred the degree of Ph. D. in 1873. During 1869 and 1870 he joined Benjamin D. Walsh, State entomologist of Illinois, in conducting The American Entomologist. As State entomologist of Missouri he issued nine annual reports on "the noxious, beneficial and other insects of the State", which in large measure laid the foundation of the science of economic entomology.

From 1873 to 1877, grasshoppers, particularly the Rocky Mountain locust, ravaged large regions in the West. Dr. Riley published "the first positive and accurate knowledge on this subject" in his last three reports. Seeing the national importance of this matter, Dr. Riley initiated a movement which led Congress in 1877 to create the United States Entomological Commission, which was primarily intended to study the Rocky Mountain locust. He was appointed chief of this commission with A. S. Packard, Jr., and Cyrus Thomas as his associates. The work of the commission was prolonged to

cover 5 years. Its five illustrated reports and seven bulletins dealt with the Rocky Mountain locust and its allies, and also with the cottonworm, bollworm, armyworm, canker worm, and insects injurious to forest trees.

In the Department Riley and his associates studied and reported on cranberry insects, silkworms, and insects affecting the orange. With a special appropriation a study of insects affecting the cotton plant was also undertaken. One of the special agents engaged in this work was John Henry Comstock, head of the department of entomology of Cornell University. L. O. Howard became assistant entomologist in 1878. In May 1879, Riley resigned to devote himself to the work of the United States Entomological Commission. Comstock succeeded him as Department entomologist and remained in that position for 2 years. Under Comstock's direction the investigation of cotton insects was completed, and a final report was published on May 18, 1880. A special report on insects injurious to sugercane was published April 28, 1881. Field studies on scale insects injurious to oranges and other citrus fruits in Florida and California were made, as well as experiments in their control. Accounts of this and other work were published in the annual reports of the Department for 1879 and 1880. On leaving the Department Comstock returned to Cornell University.

In addition to studies of a number of plant diseases, the microscopist gave considerable attention to mushrooms and prepared a bulletin on this subject.

Under special appropriations of $10,000 in 1878 and 1880, illustrated reports were made on studies of hog cholera (swine fever), fowl cholera, glanders and farcy, and pleuropneumonia. In his annual report for 1880 Commissioner LeDuc strongly advocated the establishment of a division of veterinary science.

Under F. B. Hough's direction a second report on forestry was prepared in 1879 and published in 1880. Information on forest conditions in the Western States and Territories, collected by army officers and transmitted through the War Department, was published in the report of the Department of Agriculture for 1878. Congress in 1880 included in the appropriation act of the Department an item of $5,000 for a report on forestry, and it thus became possible to give Hough a regular appointment as an officer in charge of forestry work. He gathered information on forest fires, studied the disease which was attacking spruce forests in Maine, and examined forest conditions in 14 Western States and 3 Territories. A third report on forestry was prepared in 1880 but was not published until 1882.

At this time there was much interest in the problems presented by the agricultural development of the West, particularly where rainfall was limited. In 1880 Congress appropriated $20,000 for sinking artesian wells on the plains east of the Rocky Mountains, but the results were unsatisfactory.

Commissioner LeDuc was very strongly impressed with the inadequate equipment of the Department. He advocated the purchase of a farm of 1,000 acres near Washington and at one time suggested the Arlington Estate. In addition he desired 8 or 10 stations in different parts of the country. He believed that only in this way could proper provision be made for testing and propagating the plants and seeds

intended for distribution. He recommended the erection of a laboratory building, which with its equipment would cost $300,000, and in 1880 approved a plan for a main building "in the form of a rectangular parallelogram, 500 feet by 1,000 feet, with an enclosed court for display of agricultural implements."

Commissioner LeDuc's administration was marked by definite expansion and strengthening of the Department's scientific work relating to important agricultural interests. The need of a broader realization of the important work which the Department might do if supplied with larger resources was also emphasized. Undoubtedly the mass movement of the farmer, most widely exemplified by the Grange, was creating a background of popular support which was beginning to aid the further development of the Department. The country was recovering from the financial depression of 1873, and agriculture was being rapidly expanded in the western half of the United States. This administration therefore closed with a bright outlook for the future expansion of the Department's funds and work.

ADMINISTRATION OF COMMISSIONER GEORGE BAILEY LORING, 1881–85

On July 1, 1881, George Bailey Loring (*273*) (Nov. 8, 1817–Sept. 14, 1891), of Massachusetts, became Commissioner of Agriculture. He was born at North Andover, Mass. He graduated at Harvard College in 1838 and received the degree of M. D. from the Harvard Medical School in 1842. He was surgeon to the Marine Hospital at Chelsea, Mass., from 1843 to 1850 and a commissioner to revise the United States Marine Hospital system in 1849. He moved to Salem, Mass., in 1851 and was postmaster there from 1853 to 1857. He was a member of the Massachusetts House of Representatives in 1866–67 and president of the State Senate from 1873 to 1876, when he was elected representative in Congress and served there from 1877 to 1881.

Loring became interested in scientific and practical agriculture and devoted much time to its promotion. He established an experimental farm of 450 acres in South Salem and wrote and spoke often on agricultural subjects. He founded the New England Agricultural Society in 1864 and was its president for 27 years; represented the Essex Agricultural Society on the State Board of Agriculture from 1860 to 1877; and, by the Governor's appointment, was a member of this board from 1888 to 1890. He was active in promoting the establishment and building up of the Massachusetts Agricultural College and from 1869 to 1872 lectured there on livestock farming.

Coming to the United States Department of Agriculture at a time when public interest in scientific agriculture was greatly increased, and having the support of organized agriculture and large acquaintance with public men, Commissioner Loring was able to materially expand the operations of the Department. During his administration the annual appropriations to the Department increased from $363,011 for the fiscal year 1882 to $655,930 for 1885.

Under Commissioner Loring the work on sorghum as a sugar-producing plant was continued by the Division of Chemistry. As the experiments progressed it became evident that many economic and manufacturing problems had to be solved before sugar making from this plant could be commercially successful. In 1883, at the request of Dr. Collier, the Commissioner asked the National Academy of Sciences to investigate the Department's work on sorghum. A committee of seven members, with Benjamin Silliman, of Yale College, as chairman, was appointed to make this investigation. W. H. Brewer and S. W. Johnson, of the Sheffield Scientific School, and C. A. Goessmann, of the Massachusetts Agricultural College, were members of this committee.

The report of the committee, published in 1883 (*132*) included a review of the history of the sorghum industry for 25 years, an account of the scientific investigations in this country and abroad on sorghum as a sugar-producing plant, testimony received from sugar manufacturers, and suggestions for future investigations. All members of the committee, except Dr. Goessmann, signed the report. They commended the Department's chemical and agronomic researches on sorghum as having secured results of importance toward developing a new industry of national value, and they recommended continuance of work by the Department with a view to helping the solution of the "many important practical questions, yet unsettled."

On April 10, 1883, Collier left the Department and was succeeded by Harvey Washington Wiley (Oct. 18, 1844–June 30, 1930), a graduate of Hanover (Ind.) College in 1867, the Indiana Medical College in 1871, and Harvard College in 1873, and professor of chemistry at Purdue University and State chemist of Indiana from 1874 to 1883.

Experiments in making sugar from sorghum were made during 1883 and 1884 in Washington, D. C., Indiana, Illinois, Wisconsin, and Kansas. The extraction of the juice from the stalks by the diffusion process was tried, and experiments in defecation were also made. Considerable attention was paid to the manufacture of sirup.

Sugar-beet work was continued in 1881 under a special appropriation of $10,000 for experiments in sugar making and the cultivation of beets for this purpose. Improved English and French implements for cultivating beets were obtained and loaned to a beet-sugar company. A large quantity of beet seed was distributed, and analyses of beets grown in this country were made in the Division of Chemistry. Reports received from a sugar refining company in California showed that sugar beets were being successfully grown and used in sugar manufacture in that State.

Further tea-growing experiments at Summerville, S. C., showed that the tea plant could be cultivated successfully there, but the economic problems of manufacturing tea in this country remained to be solved.

The series of illustrated descriptions of grasses by the Department botanist was concluded in the annual report of the Department for 1883, and a special publication on the agricultural grasses of the United States and their chemical composition was issued. An investigation of the chemical composition of wheat and corn grown in different parts of the country, together with analyses of flours and bread, was made, and its results published in the annual reports and in Bulletin 4 of the Division of Chemistry.

With the aid of special appropriations the investigation of fineness of wool fiber was continued, and included a careful study of "the internal structure of the fibers of purebred and grade sheep to determine the differences arising from breeding and management, and their effect upon the strength, elasticity, and felting properties." The exhaustive illustrated report on this work by William McMurtrie was completed in 1883 but was not published until 1886 (*124*).

Propagation and distribution of plants was carried to such an extent that about 100,000 plants of all kinds were sent out annually. The Bahia seedless (Washington Navel) orange was propagated extensively at Washington and young plants were sent to California and other States. The appropriations for seeds during this administration ranged from $75,000 to $100,000. In 1883 the packages distributed aggregated 2,467,230.

Plant-disease investigations were continued by the microscopist, who also made a study of parasitic fungi.

C. V. Riley returned to the Department as entomologist in July 1881, and at that time the United States Entomological Commission was transferred from the Department of the Interior to the Department of Agriculture. During this administration the Division of Entomology had an annual appropriation of $20,000. A series of bulletins by this division was begun in 1882. Among the insects studied during this administration were the scale insects affecting oranges and other plants, the armyworm, the Rocky Mountain locust, cabbage insects, canker worms, and forest-tree insects. Important experiments were made on the use of kerosene emulsions and pyrethrum for insect control. Interest in silk culture was revived at this time, and in 1884 the Department received an appropriation of $15,000 to promote this industry. Silkworm eggs and mulberry plants were distributed, as well as literature on this subject.

A distinct division of forestry was established under F. B. Hough, who made special studies of forestry in Europe, and in 1882 issued a report (*100*) which dealt with the care of forests upon the public lands, experiment stations for forest culture, influence of forests on climate, forest fires, and insect ravages. That year the forestry appropriation was increased from $5,000 to $10,000.

In 1883 Nathaniel Hillyer Egleston (May 8, 1822–Aug. 24, 1912) became Chief of the Division of Forestry. He was born at Hartford, Conn., and was trained for the ministry but became interested in forestry and wrote on this subject for magazines and other publications. When the American Forestry Congress was organized in 1882 he was elected one of its vice presidents. The work of the Division of Forestry in 1883 and 1884 was described in a report giving accounts of tree planting in the prairie States, the consumption of timber for railroad ties, the extent of land cleared of trees, and the production of maple sugar.

Commissioner Loring was strongly impressed with the desirability of strengthening and expanding the Department's work in animal diseases. Investigations on tick fever of cattle, hog cholera, and pleuropneumonia were continued. Charles P. Lyman was sent to England in the summer of 1881 and succeeded in showing the veterinarian in charge of the English quarantine against animal diseases that there was then no danger of bringing in pleuropneumonia from the United States. Dr. Salmon's repetition of his studies on hog

cholera in 1881 confirmed his findings of the previous year that a "Micrococcus" caused the disease. His investigations on tick fever led to the conclusion that a quarantine should be established between the infected and free areas, though he did not at that time believe that ticks carried this disease. The annual appropriation for investigation of animal diseases was increased to $25,000 in 1881, and in 1883 Commissioner Loring decided to give the form of a division to the organization carrying on this work.

Daniel Elmer Salmon (*301*) (July 23, 1850–Aug. 30, 1914) was appointed chief veterinarian. He was born at Mount Olive, Morris County, N. J., and entered Cornell University in 1868. He graduated with the degree of Bachelor of Veterinary Science in 1872. The last 6 months of his course had been taken at Paris in the Alfort Veterinary School. In 1876 he received from Cornell the D. V. M. degree, and the next year delivered a course of lectures on veterinary science at the University of Georgia. In 1879 he served for a few months as an inspector on the New York State force attempting to stamp out pleuropneumonia of cattle. After leaving the Department of Agriculture in 1905, he was head of the veterinary department of the University of Montevideo, Uruguay, from 1906 to 1911, and while there founded a veterinary journal. Returning to the United States he gave special attention to the preparation of hog cholera serum and during his last year was in charge of a plant for the production of this serum at Butte, Mont., where he died.

A farm near Washington, D. C., was purchased to be used as an experiment station for investigation of contagious animal diseases. Work on hog and fowl cholera and what was locally supposed to be pleuropneumonia was immediately begun there. Meanwhile, the importance of a strong central organization to study and control animal diseases, to prevent cruelty in transportation of animals, to properly inspect meat offered for sale, and to conduct an effective quarantine against importation of diseased or infected animals, was becoming widely recognized. The law regulating the transportation of animals, passed March 3, 1873, needed definite Federal enforcement. Under the act of Congress of March 3, 1883, the administration, under the Treasury Department, of quarantine laws regulating the importation of animals was strengthened by the creation of a cattle commission consisting of James Law, E. F. Thayer, and J. H. Sanders. But this commission had only advisory duties, and laws were needed to cover inspection of animals intended for export and their care during sea voyages.

On December 11, 1883, a bill (H. R. 876)—

for the establishment of a Bureau of Animal Industry (*98*, *143*), to prevent the exportation of diseased cattle, and to provide means for the suppression and extirpation of pleuropneumonia and other contagious diseases among domestic animals

was introduced in the House of Representatives and was referred to the Committee on Agriculture, of which William H. Hatch, of Missouri, was chairman. On January 26, 1884, a substitute bill (H. R. 3967) was reported to the House and was ably defended there by Congressman Hatch. There was strong opposition to this measure, but it passed the House by a vote of 155 to 127. After passing the Senate, it was approved by the President on May 29. 1884. Dr. Salmon was the first Chief of this Bureau.

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The act required that the Chief of the Bureau should be a competent veterinary surgeon. Its personnel was limited to 20 individuals, of whom 2 might be practical growers of livestock or experienced in livestock business. It was made the duty of the Commissioner of Agriculture to promulgate regulations for the suppression of pleuropneumonia and other contagious, infectious, and communicable diseases of animals, and to cooperate with the Secretary of the Treasury in establishing regulations governing the transportation and exportation of livestock. Transportation companies were prohibited from transporting diseased animals. The sum of $150,000 was appropriated to put the law into effect.

On July 1, 1884, the management of the quarantine stations for imported cattle was transferred from the Treasury Department to the Department of Agriculture and put in charge of the Bureau of Animal Industry. The Bureau immediately took such action as its limited authority and force permitted, for the location and control of pleuropenumonia, and continued the investigation of hog cholera and tick fever of cattle. Work on blackleg and on ergotism was also begun. In 1884 "it was proved by inoculation tests that swine plague in America and rouget or swine erysipelas in Europe are separate and distinct affections."

The pure-food work of the Department was begun in the Division of Chemistry in 1883 by an examination of butter from different parts of the country to establish a standard for this dairy product. Analyses were made of lard, tallow, oleomargarine, and cottonseed oil as butter adulterants. An investigation of maple sugars and sirups showed that there were many spurious or adulterated articles on the market.

In 1881 J. R. Dodge returned to the Department as statistician, and with the aid of Commissioner Loring the statistical work was materially expanded and more completely systematized. State agents were appointed, and the number of voluntary correspondents was increased to 10,000. By direction of Congress transportation rates were published in the monthly reports. "A European agency was established for the collection of statistics showing the prospective demand for American produce, especially grain and meats." For the fiscal year 1883 the appropriation for statistics was $80,000 and for 1885 it was $100,000.

To promote agricultural education and research and to associate the Department of Agriculture with the institutions, organizations, and leaders in agricultural advancement, Commissioner Loring called conventions of officers of agricultural colleges, experiment stations, boards of agriculture and societies, and experts in various branches of agriculture, which met in Washington in January 1882 and 1883. Questions relating to production of cereals, culture of grapes, wine making, animal industry, and the work of agricultural colleges and experiment stations were discussed and the proceedings of these meetings were published by the Department (*38*, *39*). Their most important result was the organization of a definite movement which led to the passage of the Hatch Experiment Station Act and the Morrill Land-Grant College Endowment Act, and the formation of the Association of American Agricultural Colleges and Experiment Stations.

ADMINISTRATION OF COMMISSIONER NORMAN JAY COLMAN, 1885–89

Norman Jay Colman (*240, 241*) (May 16, 1827–Nov. 2, 1911) (fig. 4) became Commissioner of Agriculture on April 3, 1885. He was born on a farm near Richfield Springs, Otsego County N. Y., and attended schools in that vicinity until he removed to Kentucky when 20 years old. He taught school near his New York home and at Louisville, Ky. He studied law at the Louisville Law University and received there the degree of Bachelor of Laws. He practiced law at New Albany, Ind., and at St. Louis, Mo., to which city he moved in 1852. He made his home on a stock farm near St. Louis and became a leader in the promotion of agriculture in Missouri. In 1865 he was elected a member of the Missouri Legislature and became lieutenant governor of Missouri in 1874. He established Colman's Rural World in 1865, and for two terms was president of the Missouri Press Association. He was the founder and first president of the Missouri Horticultural Society, president of the Missouri Live Stock Breeders Association, first president of the Missouri State Fair, and for 15 years a member of the board of curators of the University of Missouri. He was also president of the Missouri State Board of Agriculture, and while so serving helped to establish farmers' institutes in that State. In 1905 the University of Missouri gave him the LL. D. degree, and the same year the University of Illinois bestowed on him the D. Agr. degree.

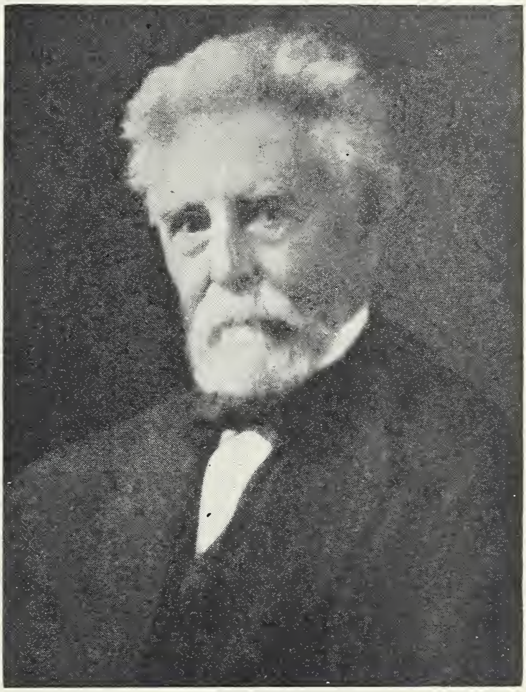

FIGURE 4.—Norman Jay Colman, 1827–1911.

The first Secretary of Agriculture; it was during his administration, 1885–89, that the Hatch Act, providing Federal funds for State agricultural experiment stations, went into effect.

The Division of Chemistry continued investigations on sugar manufacture from sorgo on a larger scale. Experiments with the diffusion process showed that the method of cutting the stalks and the type of diffusion battery employed for sugar beets could not be successfully used for sorghum, and it was only when the Department adopted machinery and apparatus devised by H. A. Hughes that the diffusion process proved successful for sorghum.

Various chemical methods for removing the impurities from the sorghum juice were tried. Precipitation with alcohol proved to be

the only successful method, but this could not be used commercially on account of its expense. Culture experiments were undertaken to produce, if possible, varieties of sorghum with a higher sugar content and freer from objectionable physical qualities, and were carried on with considerable success. The agricultural regions where sorghum could best be grown for sugar production were experimentally determined. The importance of sorghum for sirup making and for cattle food was also shown.

The interest created in the Department's experiments with the diffusion process for sorghum led to some similar experiments with sugarcane in Louisiana, the success of which aided the larger work in this direction undertaken by the Sugar Planters' Experiment Station established at New Orleans in 1885.

The Department continued to distribute sugar-beet seed and to make analyses of beets from different parts of the country.

The tea farm, which had been used to propagate plants for distribution, was abandoned by the Department in 1887, since there seemed no prospect of creating a profitable tea industry in this country.

Silk culture was promoted through the Division of Entomology with an annual appropriation of $15,000. Experimental filatures were established at New Orleans, Philadelphia, and San Francisco, but after 2 years were discontinued, and similar work was conducted at Washington, D. C. Improved reeling apparatus was installed, cocoons were purchased from growers in different parts of the country, and efforts were made to reduce the cost of silk production to a point where competition with cheap foreign labor would not entirely prevent the establishment of such an industry in the United States.

The Division of Botany continued the study of grasses and gave special attention to those suited to the more arid regions. The results of an investigation of grasses found growing in western Texas, New Mexico, Arizona, Nevada, and Utah were published in a bulletin on grasses in the arid districts. A station for experiments with grasses and forage plants was established in 1888 at Garden City, Kans., and cooperative arrangements were made with the Mississippi Agricultural College for experiments on grasses for the South.

Commissioner Colman encouraged the study of medicinal plants, in the belief that commercial cultivation of certain kinds might be established.

The herbarium which had been in the custody of the Department for 20 years had constantly received additions and by the end of Commissioner Colman's administration had become a very large and well-systematized collection of plants, worthy to be called the United States National Herbarium.

Increasing demands for information on the nature and control of plant diseases led to the establishment, on July 1, 1886, of a section of vegetable pathology. Frank Lamson-Scribner was appointed chief of this section. The section immediately prepared a bulletin on the fungus diseases of the grapevine, following this with further studies of these diseases. In 1887 an investigation of peach yellows, with Erwin F. Smith as special agent, was undertaken. Studies of potato rot and blight, as well as some diseases of other plants, were

begun. Introduction of spraying apparatus from France led to experiments resulting in improvements in such machines and their widespread use in this country. In 1888 Professor Scribner left the Department to become professor of botany at the University of Tennessee and in 1890 became director of the agricultural experiment station there. He was succeeded in the Department by Beverly Thomas Galloway (p. 213), who had been assistant pathologist since 1887.

The Division of Forestry continued to collect and publish statistics and other data relating to forestry in this country and abroad. In 1886 Bernard Eduard Fernow (Jan. 7, 1851–Feb. 6, 1923) succeeded N. H. Egleston as Chief of the Division. He was born at Inowraclaw in Posen, Prussia, and educated at the University of Koenigsberg and the Forestry Academy at Munden. In 1876 he came to the United States and engaged in business for several years, after which he had the management of private forests in Pennsylvania. He was active in the organization of the American Forestry Congress and was its secretary from 1883 to 1889. He also helped to formulate the legislation establishing the New York State Forest Reserve. After leaving the Department of Agriculture in 1898 he was director and dean of the New York State College of Forestry at Cornell University until 1903, professor of forestry at Pennsylvania State College in 1907, dean of the faculty of forestry at the University of Toronto, Canada, from 1907 to 1919, and professor emeritus there until his death. He was editor of forestry journals, and published Economics of Forestry in 1902 and History of Forestry in 1907.

Under Dr. Fernow the Division of Forestry began more definitely to disseminate information regarding the essentials of scientific forestry and to formulate and discuss in reports and addresses a national policy on forestry and particularly on what the Federal Government should do with the vast areas of public forests under its control. The public forestry agencies which were beginning to be established in a few States were encouraged in the development of their work, as were the American Forestry Congress and State forestry associations. At his own expense the forester visited the Rocky Mountain forest regions and prepared reports on the conditions there.

An outline of a plan for Federal management of the national forests was published in the report of the Department of Agriculture for 1886, and the following year a bill providing for carrying out this plan was presented to Congress through the agency of the American Forestry Congress. This bill provided for the reservation of all woodlands controlled by the Federal Government, and their classification according to their agricultural and forestry values. The timber on them was to be disposed of under a license system. For the administration of this system and to prevent loss by fire a bureau was to be established in the Department of the Interior, with a board consisting of a commissioner and four assistant commissioners.

With the cooperation of colleges and other agencies a study of the biology of timber trees, particularly conifers, was begun in 1886, and two years later technological studies were added.

A Division of Pomology was established July 1, 1886, and put in charge of Henry E. Van Deman (Nov. 3, 1845–Apr. 28, 1915). He was born in Ross County, Ohio, and was educated in the academy

at South Salem, Ohio, after which he studied botany in connection with practical work in pomology under John A. Warder, of North Bend, Ohio. In 1871 he took up a homestead claim in Kansas and made his home there until coming to the Department. In 1878–79 he was professor of botany and practical horticulture at the Kansas State Agricultural College.

After leaving the Department in 1893 he was a lecturer at farmers' institutes and before many horticultural societies in the United States and Canada. For 20 years he was associate editor of Green's Fruit Grower and for a long time a contributor to various horticultural and agricultural journals. He also was a judge of fruits at many National and State expositions.

The Division of Pomology undertook the collection of varieties of different kinds of fruits and published illustrated accounts of new varieties. A monograph on The Native Grapes of the United States, and bulletins on tropical and semitropical fruits and on Russian apples grown in the Northern States, were prepared by T. V. Munson.

The Division of Entomology made further studies and prepared reports on insects affecting cotton, oranges (including the cottony cushion scale in California), grains, forage plants and forest trees, and on the hop louse and plum curculio. Experiments with insecticides, particularly kerosene emulsions, were continued. A beginning of the introduction of parasitic enemies of injurious insects was made by bringing parasites of the cottony cushion scale into California from Australia. To provide "a speedy and regular means of publication in which might be printed short articles, notes, reports of the progress of investigation and brief papers on entomological subjects" a monthly periodical called "Insect Life" was begun in July 1888. The fourth report of the United States Entomological Commission was published in 1886.

The Bureau of Animal Industry (*152*) studied verminous bronchitis of calves and gape disease of fowls and made extensive experiments with tick fever of cattle in efforts to determine its cause. In 1886 it was determined that hog cholera and swine plague were two separate diseases, though both were frequently found in the same animal.

Tests for the prevention of hog cholera were attempted by recovering bacteria from the bodies of hogs that had died of cholera, attenuating these micro-organisms with heat and then using them on susceptible hogs for immunizing purposes. This was the first attempt made to immunize animals with killed bacterial cultures (*98, p. 57*).

The westward spread of pleuropneumonia of cattle lent great public interest to the efforts of the Bureau in cooperation with State authorities to control this disease. This could not be accomplished without authority for the purchase and slaughter of condemned animals. In making appropriations for the fiscal year 1887 Congress authorized the purchase of diseased animals when necessary to prevent the spread of this disease from State to State, but this was insufficient. Finally, in the act of March 3, 1887, authority was given to purchase and destroy both diseased and exposed animals and the Bureau's appropriation was raised from $100,000 to $500,000. The governors of 34 States and Territories immediately accepted the

Department's control regulations, and the Bureau vigorously worked toward the eradication of the disease throughout the country. "Within the first year 35,451 herds, over 300,000 head, were inspected, and 8,139 animals were slaughtered and paid for." Thus the Department began on an extensive scale the regulatory work which in later years formed a large part of its activities.

On July 1, 1886, the Division of Ornithology and Mammalogy was established. This was an outgrowth of an investigation of the economic relations of birds, undertaken the year before by the Division of Entomology. The law under which the new division was established stated that it was "for the promotion of economic ornithology and mammalogy, an investigation of the food habits, distributaries and migrations of North American birds and mammals in relation to agriculture, horticulture, and forestry."

The first chief of this Division was Clinton Hart Merriam, who had charge of similar work in the Division of Entomology. He was born in New York City December 5, 1855, studied at the Sheffield Scientific School of Yale University from 1874 to 1877, and received the M. D. degree from the College of Physicians and Surgeons of Columbia University in 1879. He practiced medicine at Locust Grove, N. Y., from 1879 to 1885 and devoted part of his time to biological investigations. He was naturalist in Hayden's Survey in 1872 and assistant in the United States Fish Commission in 1875. He published a monograph on The Birds of Connecticut in 1877 and Mammals of the Adirondacks 1882–1884. After leaving the Department of Agriculture in 1910 he undertook biological and ethnological investigations under the foundation established by Mrs. E. H. Harriman.

At first the Division of Ornithology and Mammalogy gave special attention to studies relating to the English sparrow and bobolink or ricebird. Work was also done on hawks, owls, crows, blackbirds, gophers, and small mammals attacking poultry. The examination of the stomachs of birds to determine their food habits was a special feature of the work. A bulletin on bird migration in the Mississippi Valley was published in 1887 and one on the English sparrow in 1888. Officers of the Division made field studies of the pocket gophers and ground squirrels in the West.

The pure-food work of the Department was continued. The microscopist discovered characteristic differences between the crystals of lard, beef fat, and butter. The Division of Chemistry made many analyses of milk and butter and studied the adulteration of spices, tea, coffee, and baking powders.

The Division of Statistics strengthened its crop reporting and other statistical work. About 60 persons were employed in the Department, and the field force included State agents with several thousand reporters, and over 2,300 county correspondents, each having at least 3 assistants. For the interchange of information and the promotion of scientific statistics, an International Statistical Institute was organized in 1885, with headquarters in London. J. R. Dodge became a member of this organization and attended its first biennial session at Rome, Italy, April 12, 1887.

A report on irrigation in the United States, prepared by Richard J. Hinton in response to a resolution of the Senate of August 4, 1886,

was transmitted to Congress and published as a Senate Document in 1887.

As the result of a meeting of agricultural chemists at Atlanta, Ga., in 1883, a number of official chemists interested in methods of analyzing fertilizers, met at Philadelphia, Pa., September 8 and 9, 1884, and formed the Association of Official Agricultural Chemists. Its first constitution stated that—

its object shall be to secure, as far as possible, uniformity in legislation with regard to the regulation of the sale of commercial fertilizers in the different States and uniformity and accuracy in the methods and results of fertilizer analysis.

In 1886 the constitution was amended to bring within the province of the association—

(1) to secure uniformity and accuracy in the methods, results and modes of statement of analysis of fertilizers, soils, cattle foods, dairy products, and other materials connected with agricultural industry; (2) to afford opportunity for the discussion of matters of interest to agricultural chemists.

The first president of the association was S. W. Johnson, director of the Connecticut Agricultural Experiment Station. H. W. Wiley was a member of the executive committee and in 1885 was elected president for the succeeding year. The proceedings of the Philadelphia meeting were published in the monthly report of the Board of Agriculture of South Carolina, October 1, 1884, through the courtesy of P. E. Chazal, State chemist, who had been acting secretary of the meeting. With the approval of Commissioner Colman the meetings from 1885 to 1888 were held at the Department of Agriculture in Washington, and the proceedings were published in bulletins of the Division of Chemistry.

Commissioner Colman had an important part in two large movements for the further promotion of agriculture through official agencies. In both of these enterprises he had the cordial cooperation of William H. Hatch (*255*), of Missouri, chairman of the Committee on Agriculture of the House of Representatives. To promote agricultural education and research in the States, Commissioner Colman called a convention of representatives of the agricultural colleges and experiment stations, at Washington, July 8 and 9, 1885. This led to active efforts to secure Federal aid for the State experiment stations, which resulted in the passage of the Hatch Experiment Station Act in 1887. That year a second convention was held at Washington, at which the Association of American Agricultural Colleges and Experiment Stations was formed. Under a provision of the Hatch Act the Office of Experiment Stations (*37*) was established by Commissioner Colman October 1, 1888.

For a long time many friends of agricultural progress in this country believed that the head of the Federal Department of Agriculture should have a seat in the President's Cabinet. This was actively agitated during Commissioner Colman's administration and was brought about by the passage of the act of February 9, 1889 (p. 177).

MOVEMENT IN THE STATES TOWARD THE ESTABLISHMENT OF INSTITUTIONS FOR AGRICULTURAL RESEARCH, 1840-75

While the State geological and agricultural surveys were being developed, certain friends of agricultural progress were endeavoring to secure public support for agricultural colleges, and the plans for such institutions usually included laboratories and farms for experimental purposes. Interest in the applications of science to agriculture was greatly increased by the publication of Liebig's work on Chemistry and its Applications to Agriculture and Physiology in 1840, and Boussingault's account of his agricultural experiments in Economie Rurale in 1844. The experiments of Lawes and Gilbert in England took a more organized form in 1843, and an agricultural experiment station was begun at Moeckern in Saxony in 1851. Students from the United States began to get into personal touch with the European investigators in the sciences related to agriculture and to come home with a desire to establish similar work here.

NEW YORK

An important center of agitation and work, looking toward the establishment of agricultural colleges with experimental equipment and work, was the New York State Agricultural Society with headquarters at Albany. This society had been established in 1832 as the successor of the original State Board of Agriculture, and beginning with 1841 received State appropriations for its own work and for distribution to the county agricultural societies. From that time its transactions were published as documents of the New York Legislature. It began to offer premiums for experiments and to publish the results. For example, the Transactions of 1843 contain accounts of experiments with varieties of wheat and in the manufacture of sugar from cornstalks, and in 1844 an article on the chemical examination of the rice plant and rice soil of South Carolina, by Charles U. Shepard, professor of chemistry in the Medical College of South Carolina.

The Transactions for 1844 also contains the report of the committee on agriculture of the New York Assembly, submitted March 20, 1845, by Daniel Lee, in which is an argument on the importance of applying science to agriculture and a recommendation that $5,000 a year for 3 years be appropriated to Fairfield Medical College "on condition that the institution shall be connected with a model and experimental farm, for the purpose of teaching both the science and practice of agriculture." In 1845 there was a long article by John Pitkin Norton (*287, 288*), a native of Albany, on the investigation of the potato disease in Scotland, made by the Agricultural Chemistry Association, in whose laboratory at Edinburgh he was studying. About this time he made a chemical examination of the oat plant, for which he received a medal from the Highland Agricultural Society. After his return to the United States as professor of agricultural chemistry in Yale College, he addressed the society in 1848 on The Structure, Physical Properties, and Chemical Composition of the Soil. In 1847 the society offered a prize of $300 for

experiments on Indian corn. This was won by James Henry Salisbury (*300*) (Oct. 13, 1823–Aug. 23, 1905), whose elaborate series of "chemical and physiological examinations of the maize plant during the various stages of growth" was published in 1849 in the society's Transactions for 1848. Between 1850 and 1861 he made many analyses of vegetables and fruits, some of which were published by the New York State Agricultural Society. Unfortunately, his analyses of agricultural products were made by crude methods and had no permanent value.

In 1849 the New York State Agricultural Society announced that it was prepared "to have analyses of soils, grains, etc. made by an experienced chemist." A similar arrangement was made at this time by an organization called the American Agricultural Association, with headquarters in New York City, which employed Thomas Antisell (p. 44) as its chemist. That year the society secured the indorsement by Governor Hamilton Fish of its proposition for the establishment of an agricultural college. During a discussion of this matter at a meeting of the society on January 4, 1849, Professor Norton emphasized the importance of having a strong institution,

> where could be instituted experiments of a decisive and satisfactory character, and where the management of every experiment would tend to results of more decided advantage than any we have before had, because conducted in strict accordance with established principles (*137*).

Continuing its efforts in this direction the society secured the passage of an act of incorporation of the New York State Agricultural College in 1853. A board of trustees was organized and a farm for the college purchased at Fayette in Seneca County, but the death of the president, John Delafield, in October of that year, put an end to this enterprise.

Meanwhile there had been formed an ambitious plan for a university at Albany (*2*), and a beginning of such an institution was actually made in 1851 with schools of law, medicine, and theoretical and practical science (including agriculture). The department of scientific agriculture was put in charge of Professor Norton, who opened the course in agriculture with lectures beginning January 14, 1852. A course on elementary chemistry was given by George Hammell Cook (p. 75), then principal of Albany Academy. This enterprise came to an end through lack of funds.

The New York State Agricultural Society continued to employ a chemist. In 1855 that position was filled by Ezra Slocum Carr, a graduate of Rensselaer Polytechnic Institute in 1838, and afterwards professor of chemistry as applied to agriculture at the Universities of Wisconsin and California. In the latter State he laid the foundation for its experiment station (p. 71).

CONNECTICUT

In 1846 Benjamin Silliman, Jr., was appointed "university professor of chemistry and the kindred sciences as applied to the arts" in Yale College, and the following year a "department of philosophy and the arts" was established at the college. Included in this department was a "school of applied chemistry" whose faculty consisted of Professors Silliman and Norton. This was an outgrowth of Silliman's private laboratory where he had had some students, including

Norton. The college took so little interest in this new school that the two professors had to pay for fitting up and equipping the laboratory, and for 2 years they paid rent for the use of the buiding.

To this school in 1850 came Samuel William Johnson (*265*, *266*) (July 3, 1830–July 21, 1909) (fig. 5). He was born at Kingsboro, Fulton County, N. Y., spent his boyhood in Lewis County, N. Y., and attended Lowville Academy, where he became interested in chemistry. In 1848 his father gave him a small building on the farm and fitted it up for a laboratory, and with the aid of a copy of Fresenius he began to make analyses. The next year he published Analyses of Limestone. Having decided to become an agricultural chemist he entered Yale Scientific School in January 1850.

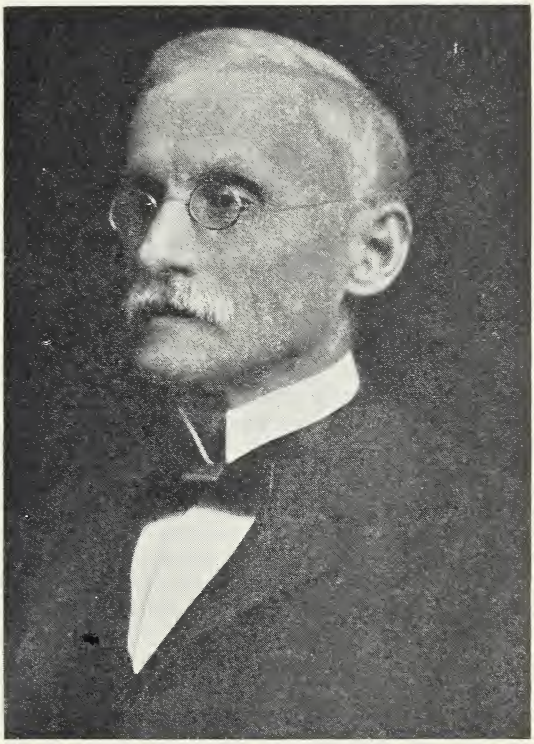

FIGURE 5.—Samuel William Johnson, 1830–1909.

A pioneer in agricultural science and a leader in the movement to establish agricultural experiment stations in the United States.

In an article on Superphosphate of Lime, in The Country Gentleman of February 1853, he discussed the value of certain commercial fertilizers as shown by his analyses of samples obtained in the open market, his object being "to show the public utility of such work." In May 1853 he went abroad for study. Writing from Munich for The Country Gentleman of February 1854 he called attention to the agricultural experiment station at Moeckern, pointing out "the great utility of such establishments, and the hope that the organization of similar ones in the United States may be encouraged."

Returning to the United States in 1855 as assistant in the laboratory of Yale Scientific School, he "resumed his work of analysis and valuation of fertilizers for the information and protection of farmers." Results of this work, published in the Connecticut Homestead, attracted wide attention and led to his appointment as chemist of the Connecticut State Agricultural Society. He became professor of analytical chemistry in 1856 and professor of agricultural chemistry in 1859. On February 13, 1856, he addressed the New York State Agricultural Society at Albany on The Relations That Exist Between Science and Agriculture (*108*), and urged that ordinary

observation and farm experiments should be supplemented by investigations in the chemical laboratory.

Just after his appointment as chemist of the Connecticut State Agricultural Society he spoke at their meeting on January 7, 1857, on Frauds in Commercial Fertilizers, and recommended that the society undertake to collect samples of fertilizers from farmers, have its chemist analyze them, and publish the results in the society's annual reports. This plan was adopted, and his first report is dated January 12, 1858. The result of this work in keeping inferior or worthless fertilizers off the market in Connecticut was remarkable and attracted wide attention.

The following year the report on fertilizers was supplemented by publication of the results of an investigation on peat and muck. The work of the Connecticut Society was interrupted by the Civil War. Professor Johnson continued his teaching and laboratory investigations at the Sheffield Scientific School and prepared his books—Peat and Its Uses as Fertilizer and Fuel (1866), How Crops Grow (1868), and How Crops Feed (1870). He also had relations with the Massachusetts Board of Agriculture and aided S. L. Goodale, secretary of the Maine Board of Agriculture, by making analyses of fertilizers and in other ways.

In August 1866 the Connecticut State Board of Agriculture was organized, with the active cooperation of Professor Johnson. Its first annual meeting was held at the Sheffield Scientific School, when he addressed it on the source and supply of nitrogen to crops, and the selection and use of fertilizers. Beginning with 1869 he made annual reports on commercial fertilizers to the board. The report for this year had an additional interest because it contained analyses made by W. O. Atwater, who was studying under Johnson and acting as his laboratory assistant. In a similar way E. H. Jenkins began work with Johnson in 1873. That year a report on ash of tobacco was made to the State Board of Agriculture.

Professor Johnson was a delegate to the convention held at Washington in 1872 in response to an invitation by Commissioner Watts, of the Department of Agriculture, at which the experiment station movement was discussed and definitely promoted. This led to systematic efforts under Professor Johnson's leadership to bring about the establishment of an experiment station in Connecticut.

Before describing the events which led up to the organization of the Connecticut Experiment Station it seems best to consider the early work in agricultural research in a number of other States.

CALIFORNIA

The California (*203*) Constitution of 1849 directed the legislature to "encourage by all suitable means the promotion of * * * agricultural improvement." The law incorporating the California State Agricultural Society in 1854 authorized it to purchase and hold land for "a model experimental farm." In 1859 Wilson Flint, reporting on pomology to the society, said that "for the successful collection and experimental trial and proper distribution" of fruits and other plants which might be grown in California there should be a place "presided over by a botanist of the highest abilities", and he believed that this could "only be done by legislative endowment." The Uni-

versity of California was established in 1868, and the following year Ezra S. Carr (p. 68) was elected "professor of agriculture, chemistry, agricultural and applied chemistry and horticulture." At the State fair of 1870 Professor Carr said that the university "proposes to furnish the facilities for all needful experiments; to be the 'station' where tests can be made of whatever claims attention; to become the exponent and repository of our progressive knowledge." But he was not permitted "to plant a tree or make a single experiment on the grounds of the University." This was because of a provision in the organic act of the university that the secretary of the board of regents should be "a competent person, who is a practical agriculturist by profession, competent to superintend the working of the agricultural farm." This was not changed until May 10, 1879, when the regents voted that a certain portion of the university grounds should "be set apart for the culture of economic plants under the direction of the professor of agriculture."

Meanwhile the discontent of the farmers compelled the university to do something for agricultural experimentation. On December 1, 1873, President D. C. Gilman announced—

> The University domain is being developed with a view to illustrate the capability of the State for special cultures, whether of forests, fruits, or field crops, and the most economical methods of production. It will be the station where new plants and processes will be tested and the results made known to the public. * * * A fine estate has been provided, well adapted to the establishment of an experiment station in agriculture, a botanic garden, an arboretum, etc. (*203, p. 41*).

The secretary of the board of regents, R. E. C. Stearne, in his report for 1873–75, made the following statement:

> Forty acres were prepared for planting with a view to agricultural experiments in 1874; and there were planted five hundred and eighty-four named varieties of tree fruits, seventy-three of grape-vines, and ninety-five of various small fruits. The purpose of such plantation is to furnish means of correcting the nomenclature of the fruits already in cultivation, and for supplying hereafter scions and plants for distribution throughout the State, as well as for the introduction of new varieties (*203, p. 41*).

In 1874 Professor Carr was succeeded by E. W. Hilgard (fig. 6), who came from the University of Michigan, and the following year organized an experiment station (p. 87).

MARYLAND

The act to establish and endow an agricultural college, passed by the Legislature of Maryland in 1856, contains the following section:

> SEC. 6. It shall be the duty of the said board of trustees to order and direct to be made and instituted on said model farm, annually, a series of experiments upon the cultivation of cereal and other plants adapted to the latitude and climate of the State of Maryland, and cause to be carefully noticed upon the records of said institution the character of said experiments, the kind of soil upon which they were undertaken, the system of cultivation adopted, the state of the atmosphere, and all other particulars which may be necessary to a fair and complete understanding of the result of said experiments, and they shall also require the instructor of Chemistry as far as may be consistent with his other duties in said Institution, to carefully analyze all specimens of soil that may be submitted to him by any citizen of this State, free of charge, and specially furnish the applicant with an accurate statement of the result.

The records of the college show that in 1858, immediately after the college was located, and before building began, field experiments with corn, oats, and potatoes, "to test the relative value of the different manures offered for sale in the cities of Baltimore and Washington", were commenced on the college farm. This work continued for 2 or 3 years, but was interrupted by the financial distress and the disturbed political condition of the State and Nation.

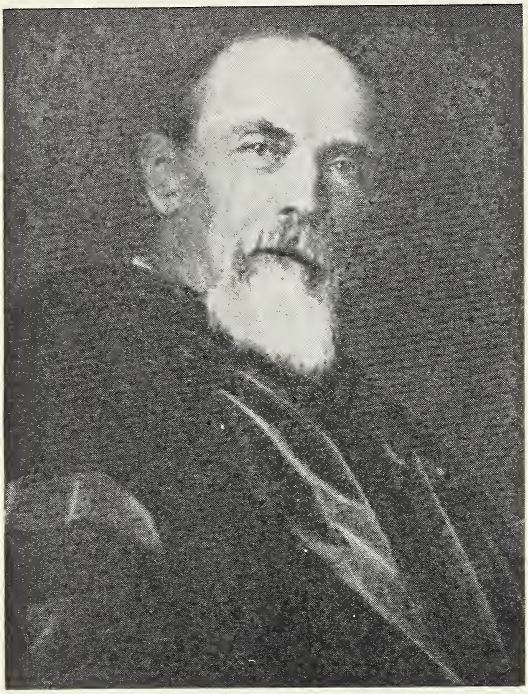

FIGURE 6.—Eugene Woldemar Hilgard, 1833–1916.
A leader in agricultural research and in the movement to establish agricultural experiment stations in the United States.

PENNSYLVANIA

The Pennsylvania State Agricultural Society was organized in 1851, with Frederick Watts as its president. Two years later the society called a convention, which recommended the establishment of "The Farmers' High School of the State of Pennsylvania." An act of April 13, 1854, gave this school a charter. Judge Watts was elected president of the board of trustees.

In a memorial to the legislature (*123, p. 109*), asking for a State appropriation for the school, a committee of the board of trustees said that agricultural experiments are generally too troublesome and expensive for the individual farmer.

> At this school, however, which will be in correspondence with agricultural institutions in every part of the civilized world, experiments can be made with great facility and certainty, and at a comparative trifling cost, and the results be made known to all the citizens of the Commonwealth without charge.

An act of May 20, 1857, provided that an office should be established at the school for the analysis of soils and manures sent in by citizens and that reports of experiments with plants, soils, and livestock should be sent monthly, or as soon as results are available, to at least one paper in each county.

The gift of a farm of 200 acres in Center County, near Bellefonte, was accepted, and 200 additional acres were purchased. On this land a substantial stone building was erected, and the school was opened February 16, 1859, with William G. Waring as general superintendent and professor of horticulture. Meanwhile orchards

of different varieties of peaches, apples, and pears were planted; and a nursery of fruits, vegetables, and ornamentals for sale, was established, a catalog of which was published in 1859. Grain crops were also grown, and in 1857 Hugh N. M'Allister, who had a farm near Bellefonte and was one of the incorporators of the school and a trustee until 1873, supervised the laying out of experimental tracts on the school farm, and planned experiments in rotation of crops and the application of fertilizers. One hundred and ten varieties of wheat were grown that year.

In 1860 Evan Pugh (*293*) (Feb. 29, 1828–Apr. 29, 1864) became president of the school. He was born at Jordan Bank, Chester County, Pa., became a blacksmith's apprentice, studied at the Manual Labor School at Whitestown, N. Y., and had charge of a small academy in his native place. In 1853 he went to Germany and studied chemistry in the Universities of Leipzig, Göttingen, and Heidelberg, and in Paris, receiving the Ph. D. degree at Göttingen in 1856. He went to Rothamsted, England, in 1857 and in the laboratory of J. B. Lawes made an investigation on the assimilation of free nitrogen by plants. At Leipzig he made the acquaintance of S. W. Johnson, who was studying there, and who afterwards suggested to the trustees of the Farmers' High School his appointment to the presidency of that institution. There he also taught chemistry, mineralogy, geology, and agriculture. Having visited many of the agricultural institutions of Europe, he had a broad conception of what an agricultural college ought to be (*147*). In 1862 he secured a change of name of the Farmers' High School to Agricultural College of Pennsylvania. At that time he stated that the college aimed to be both an educational and experimental institution, to develop the principles of agricultural science and to act as a means of protecting the agricultural interests from the sale of bad or worthless or too high-priced materials and implements used in agriculture. A few experiments upon the manufacture, preservation, and use of manures had been begun.

Dr. Pugh participated to a limited extent in chemical studies at the college until his death in 1864. Some work was also done by George Chapman Caldwell, appointed professor of chemistry that year. He had studied in the Universities of Göttingen and Heidelberg from 1855 to 1858 and in 1868 became professor of agricultural and analytical chemistry at Cornell University. Most of the experimental work at the Pennsylvania College for the first 10 years consisted of variety tests of field crops and horticultural plants, and simple experiments with fertilizers, methods of culture, and farm implements.

Under a State act of February 19, 1869, one-tenth of the land-grant fund was required to be used for the purchase of three experiment farms in the eastern, central, and western parts of the State, and $2,000 was appropriated annually for the maintenance of each farm. The work on all these farms was under the general direction of the professor of agriculture. At first the president of the college, Thomas H. Burrowes, was also professor of agriculture; but in 1871 John Hamilton (*254*), a farmer living in the vicinity of the college, who had taken an agricultural course there and received the M. A. S. degree, was appointed professor of agriculture. William C. Patter-

son, superintendent of the college farm, also had much to do with the experimental work there. On the central farm a large number of field experiments were carried on, and a lesser number were also made on the outlying farms. The work included experiments with varieties of corn, wheat, barley, oats, clover, timothy, and potatoes, fertilizers, lime, subsoiling, deep and shallow plowing, different amounts of seed, times of planting, and rotation. These experiments were without laboratory checks and with some exceptions were not satisfactory.

MICHIGAN

The Michigan Agricultural College was established under an act of February 12, 1855, and opened for students in 1857 (*19*). In the organic act the purpose of the college was stated to be the improvement, as well as the teaching, of the science and practice of agriculture, and the purchase of an experiment farm was provided for. The farm selected for the college at East Lansing was covered with forest trees, and clearing of the land and putting it in condition for farm operations, together with the erection of buildings, occupied the attention of the trustees, faculty, and students during the first 6 years of the existence of the college. Plantings of field crops, fruits, and vegetables were made, which in a broad sense were experimental, being for the most part such as were likely to grow under pioneer conditions on land where tree stumps were numerous.

An Act of March 15, 1861, established a State Board of Agriculture, and transferred the college to its control from that of the State Board of Education. Under this act the State Board of Agriculture was directed to conduct scientific and practical experiments, as soon as practicable, for the instruction of the students and the promotion of the progress of agriculture, and to cause the results to be published in the annual reports of the board.

The faculty thereupon formulated a plan for more systematic experiments and suggested that the college might well carry on experiments in different parts of the State. In 1862 about 250 acres of the college farm were used for crops. "A portion of this is entirely destitute of stumps." Some experiments with varieties of vegetables were made that year. Up to this time the superintendent of the farm had full charge of all the operations on the college farm, but now the board ruled that—

> the faculty shall decide upon the experiments to be made and the manner of conducting the same; and shall appoint some one of their number to superintend such experiments. Each officer having in charge any experiment shall keep a full record of his proceedings in conducting the same.

In 1863 Robert Clark Kedzie (*268*, *269*) (Jan. 28, 1823–Nov. 9, 1902), who had come to the college that year as professor of chemistry, had charge of the experiments. He was born at Delhi, N. Y., graduated at Oberlin College in 1847, and from the medical department of the University of Michigan in 1851. The experiments in 1863 "consisted in the use of top dressings and of manuring in the hill with salt, muck, night-soil, etc. on grass, corn and potatoes." The results, combined with some chemical studies on the absorptive properties of soils, on muck, and on the influence of the color of soil on its temperature, were given in public lectures at the college and in the report

of the board of agriculture for 1863. Field and laboratory experiments along similar lines were conducted by Dr. Kedzie for a number of years. In 1866 as part of this work, to test the effect of the volatile constituents of manures, nine jugs were filled with wet manures and connected with lead tubes, the open extremities of which were inserted in hills of corn, so that the volatile products of the fermentation of the manures might be conveyed to the soil. The result showed a large increase of grain from the volatile products of the manure.

In 1864 Manly Miles (*278*) (July 20, 1826–Jan. 16, 1898), who had come to the college in 1861 as professor of zoology and animal physiology, was given charge of the farm and in 1865 became professor of animal physiology and practical agriculture and farm superintendent. He was born at Homer, Cortland County, N. Y., but moved to a farm near Kent, Mich., when 11 years old. He graduated at Rush Medical College, Chicago, in 1850 and practiced medicine in Michigan until 1859, when he became assistant State geologist. In this capacity he made collections and a catalog of mammals, birds, reptiles, and mollusks.

As professor of agriculture he continued the experiments on manures and fertilizers and began experiments with animals. His experiments with different rations for pigs and sheep, carried on from 1866 to 1873, were systematically planned and carefully conducted.

In 1873 William James Beal (*223*) (Mar. 11, 1833–Apr. 12, 1924), who had come to the college as professor of botany and horticulture in 1871, began experiments in the cultivation and manuring of apple trees. Professor Beal was born at Adrian, Mich., graduated with the A. B. degree at the University of Michigan in 1855, studied under Asa Gray and Louis Agassiz at Harvard University, receiving there the B. S. degree in 1865, and was professor of natural history in the old Chicago University from 1869 to 1871.

NEW JERSEY

In New Jersey agricultural research was an outgrowth of the work of the State Geological Survey, conducted by George Hammell Cook (*242*, *243*) (Jan. 5, 1818–Sept. 22, 1889) between 1854 and 1856 (p. 15). He was born at Hanover, N. J., graduated in civil engineering at Rensselaer Polytechnic Institute in 1839, and studied science and taught there from 1842 to 1846, receiving the B. S. and M. S. degrees. In 1852 he was sent to Europe by the State of New York to study the European salt deposits in relation to the development of those in Onondaga County. In 1853 he became professor of chemistry and natural philosophy in Rutgers College, New Brunswick, N. J.

After work on the geological survey of New Jersey was suspended in 1856, he continued chemical studies relating to the marls, limestones, and soils of the State. Largely through his influence the New Jersey Legislature, by an act of April 4, 1864, designated Rutgers Scientific School as the State College of Agriculture and Mechanic Arts and made it the beneficiary of the Federal Land Grant Act of 1862. The trustees of Rutgers College were required by the law to "provide a suitable tract of land conveniently located for an experimental farm." That year a farm of 100 acres was purchased, and

field experiments with fertilizers were begun in 1865. Experiments in tile drainage and with varieties of cereals, potatoes, and other vegetables were soon added.

Professor Cook became vice president of Rutgers College in 1864, and 2 years later agriculture was added to the title of his professorship. In 1870 he visited agricultural institutions in a number of countries in northern Europe. In February 1872 he attended the convention held at the Department of Agriculture in Washington (*43*), at which the States were requested to organize boards of agriculture. On his return home he secured the passage of the act of April 4, 1872, establishing the New Jersey State Board of Agriculture, and was appointed its secretary. Its first meeting was held at the college farm, September 4, 1872. This board included the board of managers and superintendent of the State geological survey, the president and two professors of the State agricultural college, three members of the board of visitors of the college, and the presidents or other representatives of the State and county agricultural societies. The law provided that the board might investigate subjects relating to the improvement of lands and agriculture and receive gifts for promoting scientific education or the general interests of agriculture. This board secured the passage of the act of March 24, 1874, for the control of fertilizers, under which it undertook the inspection and analysis of fertilizers sold in the State.

MASSACHUSETTS

In Massachusetts the earliest definite plan for an agricultural college, which was made in 1825, included a farm with soil "best adapted to agricultural experiments", the experiments to be recorded in a journal "kept by the students and published semi-annually." And the movement, begun by Marshall P. Wilder in 1849, which resulted in the establishment of the Massachusetts Agricultural College at Amherst, made experimental work one of the functions of such an institution. The bill for an agricultural college which passed the Massachusetts Senate in 1850 had a provision for an "experiment farm." In speaking on this matter before the Berkshire Society in 1851, Wilder said, "We want a system of experiments directed by scientific knowledge" (*204*). Edward Hitchcock's report favoring an agricultural college in Massachusetts, after his visit to European agricultural institutions in 1851, advocated for this college a "model and experimental farm of from 100 to 200 acres." Therefore the board of trustees appointed under the act of April 1863, incorporating the Massachusetts Agricultural College, declared in 1866 that it should give special attention to experiments and investigations to advance knowledge.

Lands aggregating about 384 acres were purchased or controlled by the college, and in 1866 Levi Stockbridge (*305*, *306*) (Mar. 13, 1820–May 3, 1904) was appointed farm superintendent and instructor in agriculture. In 1870 he became professor of agriculture. He had been a farmer in the nearby town of Hadley, where he was born. He attended academies in that vicinity and took special courses in chemistry and other natural sciences at Amherst College. He had a small laboratory on his farm and read the works of Liebig, Lawes,

and Gilbert. He was a member of the State Senate, where, as chairman of the committee on agriculture in 1865 and 1866, he was active in promoting legislation for the benefit of the college. He was on the State Board of Agriculture for 12 years. In 1868 he was chairman of the first board of cattle commissioners and served on this board 27 years.

In 1867 he began experiments with commercial fertilizers and 2 years later a more systematic investigation based on the theory that the plant, rather than the soil, should be fed and that the nutrition needs of the plant should be determined by its chemical composition. Soils from different parts of the college farm and from adjoining farms were placed in pots in the plant house and in them were sown seeds of various crops. The plants—

were fed from time to time with the chemical elements which they were known to contain, and in an absolutely soluble condition. The elements were occasionally varied and sometimes compounded in such proportions as they had been found to exhibit in the several varieties.

After 2 years of this work, soils and plants "placed in large boxes in the open air" were used during 1871 and 1872. From these experiments it appeared that "the only substances the farmer must supply were nitrogen, potash and phosphoric acid; and second, that there was a marked relation between the quantity of the crop produced and of the elements applied, if these elements were mixed in such proportion as they exhibit in the entire plant which was being fed" (*159, p. 59*).

In 1872 and 1874 similar experiments were made on a variety of soils with wheat, rye, corn, oats, potatoes, grass, and tobacco. The professor of chemistry, C. A. Goessmann, cooperated in this work.

Charles Anthony Goessmann (*252, 253*) (1827–1910), became professor of chemistry at the Massachusetts Agricultural College in 1868. He was born at Naumburg, Germany, entered the University of Göttingen as a student of pharmacy in 1850 and served as an assistant in the chemical laboratory there prior to receiving the Ph. D. degree on December 27, 1852. During his connection with the university he made important researches and discoveries in organic and analytical chemistry.

In 1856, in connection with G. C. Caldwell of Cornell University, then a student at Göttingen, Goessmann began an investigation of the Chinese sugarcane (*Sorghum saccharatum*) and continued this in the United States in 1857. The elaborate monograph resulting from this study was published in the Journal für Landwirthschaft and in 1862 in a pamphlet reprinted from the Transactions of the New York State Agricultural Society for 1861 (*73*). Goessmann came to the United States in 1857. From that year to 1868 he was connected with commercial concerns and made investigations with special reference to the sugar and salt industries.

At Amherst Goessmann analyzed commercial fertilizers and studied the problems connected with their manufacture and use. His report on this subject in January 1873 led to the enactment of the Massachusetts Fertilizer Control Act of May 26, 1873, the first law in the United States providing for an official inspection of fertilizers. He then became ex officio a member of the State Board of Agriculture, and State inspector of fertilizers.

Beginning in 1870 he made field experiments and chemical studies with sugar beets from seeds of a number of varieties grown in Germany. The report on this investigation, published in 1874, attracted wide attention as indicating that beets of good quality for sugar making could be grown in the Northeastern States when proper attention is given to soil, fertilization, and cultivation. Other important investigations begun by Goessmann in this period were those on the reclamation of salt marshes, and, with his assistant, D. P. Penhallow, on the physiological effect of special chemical fertilizers on the carbohydrate content of grapevines and the quality of the fruit.

The president of the college and professor of botany and horticulture from 1867 to 1875 was William Smith Clark (*236*, *237*) (July 31, 1826–Mar. 9, 1886). He was born at Ashfield, Mass. He received the A. B. degree at Amherst College in 1848 and the Ph. D. degree at the University of Göttingen in 1850. For 15 years he was professor of chemistry, botany, and zoology at Amherst College. From 1859 to 1861 he was a member of the State Board of Agriculture. As a member of the Massachusetts Legislature between 1864 and 1867 he was influential in promoting legislation in the interests of the college. In 1873 and 1874 he made a comprehensive study of the circulation of sap in trees, especially the sugar maple, in which he was aided by several members of the faculty; and in 1874, with Penhallow, he made an experimental study on the growth, root development, and expansive force of growth of the squash, which gave quite striking results.

The Lawrence Scientific School of Harvard University, established in 1847, had on its first faculty Eben Norton Horsford (1818–93), as Rumford professor of science in its application to useful arts. He had studied chemistry under Liebig from 1844 to 1846, and in the latter year published analyses of grain and vegetables, with special reference to their nutritive value on the basis of their nitrogen content (*95*). While at Harvard he continued studies in the field of agricultural chemistry, including those relating to improvements in the art of making cider, the manufacture of condensed milk, and a phosphatic yeast powder.

Bussey Institution (*78*) of Harvard University, located at Jamaica Plain, Mass., resulted from the will of Benjamin Bussey, of Roxbury, Mass., signed July 30, 1835, and probated in 1842. This will bequeathed 200 acres of land in Roxbury and half of the income from about $300,000 to the president and fellows of Harvard College on condition that they establish on the farm—

> a course of instruction in practical agriculture, in useful and ornamental gardening, in botany and such other branches of natural science as may tend to promote a knowledge of practical agriculture and the various arts subservient thereto.

Owing to other provisions of the will it was not deemed advisable to begin the formation of the Bussey Institution earlier than 1870. As directed in the will a stone edifice, with a laboratory and classrooms and a glasshouse, was built on the Bussey estate. The laboratory was not equipped and occupied until the end of 1871. Meanwhile the trustees of the Massachusetts Society for Promoting Agriculture had granted $3,000 annually for 5 years, "for the support of a labora-

tory and for experiments in agricultural chemistry, to be conducted on the Bussey estate." In 1872, under the will of James Arnold of New Bedford, Mass., Harvard University received $100,000 for a professorship of tree culture and an arboretum in connection with the Bussey Institution.

On November 25, 1870, Francis Humphreys Storer (*307*) (Mar. 27, 1832–July 30, 1914) was appointed professor of agricultural chemistry and in 1871 dean of Bussey Institution. He was born at Boston, Mass., and graduated with the B. S. degree at the Lawrence Scientific School of Harvard University in 1855. For the next 2 years he studied at the Royal Academy of Agriculture at Tharandt, Germany, under Stöckhardt, at Heidelberg under Bunsen, and in Paris under Boussingault. Then he was a consulting and analytical chemist in Boston until 1865 when he became professor of general and industrial chemistry in the new Massachusetts Institute of Technology. There he became associated with Charles W. Eliot, then professor of analytical chemistry and metallurgy. Together they prepared A Manual for Inorganic Chemistry (1866) and A Compendious Manual of Qualitative Chemical Analyses (1868), which passed through several editions. In 1870 and 1873 Storer published A Cyclopedia of Quantitative Chemical Analysis in two parts.

In 1871 Professor Storer and his assistants began field tests of fertilizers upon the farm at Bussey Institution and made analyses of commercial fertilizers. The first report was presented to the trustees of the Massachusetts Society for Promoting Agriculture on December 3, 1871. Twenty-five bulletins were issued between 1874 and 1876. Most of these recorded Storer's work on fertilizers, but there were also a number of articles on plant diseases and fungi by W. G. Farlow, and two reports by C. S. Sargent, as director of the Arnold Arboretum. The great fire in Boston in 1872 and the commercial crisis of 1873 combined to cripple the Bussey Institution financially and for a number of years little was done in the way of original investigations.

MAINE

At the Maine State College of Agriculture and Mechanic Acts (now University of Maine), at Orono, field experiments were begun very soon after the opening of the college in 1868 (*66*). The annual report of the college for 1870 (*107*) gives an account of a test of 61 varieties of potatoes, fertilizer experiments with beans, and a pig-feeding experiment. The latter was to compare raw versus cooked corn meal in rations for pigs and was continued for nine years. The experiment with varieties of potatoes was continued for 4 years and was followed by experiments with fertilizers and in planting pieces of different sizes. Before 1875 there were also experiments on beans, beets, and grass. At first the experiments were in charge of Samuel Johnson, a graduate of Bowdoin College, who was succeeded in 1871 by Joseph R. Farrington.

KANSAS

In Kansas the charter of Bluemont Central College (*196*) at Manhattan, which was approved February 9, 1858, provided for the establishment of a separate department, with a farm on which soil

tests and crop experiments were to be made to demonstrate the agricultural advantages of Kansas and especially of its high prairie land.

When this college was given to the State and became the Kansas State Agricultural College in 1863, it had a farm of 100 acres. This, however, was "a dry and stony piece of upland" and no experimental plantings were made on it until in 1867 when 500 forest trees of various kinds, 200 apple trees, and a small number of other fruit trees were set out there. In 1871 a tract of about 160 acres, the site of the present college, was purchased. Then were begun more systematic experiments with varieties of forest and fruit trees, grapes, wheat, and other cereals. There were also in 1872 some experiments with fertilizers, soil preparation, and methods of planting. Alfalfa was grown for the first time in 1875, from seed obtained in California.

ILLINOIS

The bill establishing the Illinois Industrial University was drafted in 1864 by a committee of which J. B. Turner (*316*) was a member. It contained a provision which made it the duty of the corresponding secretary of the board of trustees

> to issue circulars, directions for procuring needful materials for conducting experiments and eliciting instructive information from persons in various counties, selected for that purpose, and skilled in any branch of Agricultural, Mechanical and Industrial Art,

and to prepare an annual report "recording any improvements and experiments made, with their costs and results." Not fewer than 5,000 copies of this report were to be printed and distributed. In an address at the county fair at Monmouth, Ill., October 4, 1866, Turner explained that it was intended that—

> gratuitous experiments in agriculture and the arts should be annually made, under the direction of the County Superintendents, of each crop of special interest, in all the counties of the State. * * * Thus the whole State, and eventually the whole Union, will become one vast experimental farm.

Willard C. Flagg was elected corresponding secretary in 1867, and in his first report outlined the fields in which the university should carry on investigations. These included analyses and tests of soils and subsoils to determine the crops and manures best suited to each, and studies in meteorology, botany, and zoology, especially entomology. He expressed his belief that farmers could be used as experimenters. It soon appeared that this plan of experimentation was not feasible. In 1870, an arrangement was made for Manly Miles, of the Michigan Agricultural College, to give part of his time to the Illinois Industrial University, and he showed that good experimentation required special training and skill. Therefore in his third report Mr. Flagg advocated "agricultural experiment stations at the university and in different parts of the State." At the Chicago convention of August 24 and 25, 1871, representatives of agricultural colleges from 11 States discussed the experimental work of such institutions (p. 118). Dr. Miles took a leading part in this meeting. He and others said much about the difficulties in making field and feeding experiments. The convention voted in favor of having at least one agricultural experiment station in each State.

Meanwhile the Illinois Industrial University had set apart 200 acres of land near the college buildings as an experiment farm. This tract was divided into three parts for experiments with forest trees, field crops, and orchard and other fruits and vegetables. In 1871 Flagg had charge of experiments on about 50 acres, with fertilizers, methods of cultivation, and varieties. This plan was followed for several years. In 1872 it included tests of the comparative fertility of adjacent plats; ordinary versus frequent cultivation, planting in hills versus drills, and different depths of plowing for corn; tests of varieties of corn, wheat, barley, oats, broomcorn, clovers, grasses, potatoes, sugar beets, rutabagas, carrots, and parsnips. About this time some experiments in feeding cattle on different rations were begun.

In 1870 Thomas Jonathan Burrill (*232*) (Apr. 25, 1839–Apr. 14, 1916) was appointed professor of botany and horticulture. He was born at Pittsfield, Mass., graduated at the Ilinois State Normal University in 1865, and was a member of Powell's first Rocky Mountain expedition in 1867. The next year he became assistant professor of natural science at the Illinois Industrial University.

The importance of encouraging the growth of forest trees on the prairies had been recognized from the beginning by the university authorities. Varieties of such trees were grown in a nursery, and in 1871 a forest plantation was begun. Under Professor Burrill this was enlarged and carefully managed, with useful results. A large number of varieties of apples and pears were planted, and tests of varieties of small fruits and vegetables were also made.

In 1871 Professor Burrill began the microscopical observations on diseases of fruits which after a few years gave important results (p. 108). That year he studied fire and leaf blight of pears, showing its bacterial origin, twig blight of apples, and the rotting of grapes and stone fruits.

While the university was beginning agricultural research, official entomological studies were being made in Illinois by Benjamin Dann Walsh (*319*) (Sept. 21, 1808–Nov. 18, 1869). He began work as State entomologist in 1867 but made only one report. He was born at Frome, Worcestershire, England, graduated at Cambridge University, came to the United States in 1838, and settled on a farm in Henry County, Ill. He engaged in the lumber business for seven years, but retired from it and began systematic entomological observations, writing frequently on this subject for periodicals. When The Practical Entomologist was founded in 1865 in Philadelphia he became its associate editor and ultimately its editor. With C. V. Riley (p. 54), who was then State entomologist in Missouri, he established The American Entomologist in 1868.

MINNESOTA

In Minnesota an experiment farm was purchased when the College of Agriculture of the University of Minnesota was organized in 1868, but little experimental work was done on this farm for several years. The report of the assistant professor in charge of agricultural work in the college shows that in 1874 the principal experiments were variety tests of wheat, oats, tomatoes, cabbage, beets, eggplant, and squash.

WISCONSIN

The University of Wisconsin, as reorganized in 1866, included a college of arts, in which there was a department of agriculture. In 1868 William W. Daniells was appointed professor of agriculture and analytical chemistry. A portion of the university land was set apart as an experiment farm. Here, between 1868 and 1875, Professor Daniells conducted experiments (*48*, *49*, *50*, *51*, *52*), including tests of varieties of wheat, corn, oats, barley, buckwheat, potatoes, sugar beets, different amounts of wheat seed per acre, seed from the tips, middle, and butts of ears of corn, and different depths of plowing for corn. In 1872 the test of Manshury barley, which afterwards became an important crop in Wisconsin, was begun with seed from the farm of H. Grunow, of Mifflin, Wis., who had successfully grown this variety from 1862. Reports of this early experimental work of the University of Wisconsin were published in the annual reports of the board of regents of the university.

IOWA

Iowa State Agricultural College was opened to students in 1869. Two years later Charles E. Bessey, as instructor in botany and horticulture, tested varieties of potatoes, tomatoes, cabbages, beets, and sweet corn. James Mathews, professor of pomology, planted varieties of apples, pears, cherries, grapes, and forest trees. In 1872 I. P. Roberts (p. 94), as farm superintendent, made experiments with corn, including manuring, planting in hills v. drills, and growing different numbers of stalks in a hill.

STATE AGRICULTURAL EXPERIMENT STATIONS WITHOUT FEDERAL AID, 1875–88

CONNECTICUT EXPERIMENT STATION (*35*)

After returning from the Washington Convention of Agricultural Colleges in 1872 (p. 70), S. W. Johnson undertook active propaganda for the establishment of an agricultural experiment station in Connecticut. At the meeting of the State Board of Agriculture at Meriden on December 17, 1873, there was much discussion of the work of the German experiment stations by Johnson, W. H. Brewer, professor of agriculture in the Sheffield Scientific School, and W. O. Atwater, who spoke on Commercial Fertilizers at Home and Abroad.

Wilbur Olin Atwater (*220*) (May 3, 1844–Sept. 22, 1907) (fig. 7) was born at Johnsburg, N. Y., graduated with A. B. degree at Wesleyan University, Middletown, Conn., in 1865, and received the Ph. D. degree in 1869 at Yale University, where he studied agricultural chemistry under Johnson. He then spent two years studying agricultural and physiological chemistry at the Universities of Leipzig and Berlin, and visiting the agricultural institutions in several European countries. In 1871 and 1872 he was professor of chemistry at the University of Tennessee and for a short time in 1873 at the Maine State College. Later in that year he became professor of chemistry at Wesleyan University.

Johnson, as chairman of a committee appointed at the Meriden meeting, reported the unanimous opinion of its members that—

the State of Connecticut ought to have an experiment station as good as can be found anywhere, and they are of the opinion that the Legislature of the State ought to furnish the means for its immediate establishment and for carrying it forward. They recommend that a permanent committee be appointed by this convention to do such work as is necessary to bring this matter before the people and before the Legislature, and to accomplish the desired result either by direct legislative action or by whatever means may be necessary to effect it, this committee to begin now and to work until the thing is done (*36*).

FIGURE 7.—Wilbur Olin Atwater, 1844–1907.

A pioneer in agricultural experiment station work in the United States, and the first director of the Office of Experiment Stations of the United States Department of Agriculture.

The report was adopted, and a committee with one member from each of the eight counties of the State was appointed. At the request of this committee the board held 17 meetings in different parts of the State. At these meetings Professors Johnson and Atwater and others discussed the establishment of an experiment station. At the meeting of the board December 16–18, 1874, Professor Atwater gave an account of the European experiments on the feeding of cattle, and the experiment station committee presented a report. In addition to the meetings above referred to, petitions for an experiment station had been presented to the legislature, a bill for a station had been drafted and introduced in the legislature, and a hearing before the committee on agriculture had been attended by the committee of the board and "a strong delegation of our leading farmers." This bill, which called for an appropriation of $8,000 for the maintenance of a station, had been held by the committee on agriculture "until near the close of the session and then reported with the recommendation that it be laid over to the next session of the General Assembly."

In the course of the discussion of the report of the board's committee, Orange Judd (*267*), editor of the American Agriculturist and a trustee of Wesleyan University, proposed that the farmers interested in having a station immediately form an association,

raise $1,000 by subscription, hire a chemist, and begin work in analyzing fertilizers. They could have a room in the Orange Judd Hall at Wesleyan University, and Professor Atwater would give part of his time to supervising the work. No action on this proposition was taken by the board, but its committee on an experiment station was continued. A second series of farmers' meetings was held, an account of the European experiment stations by Professor Johnson was widely circulated, and more petitions were sent to the legislature. The committee's bill was again presented to the legislature and discussed at hearings before the committee on agriculture, but without definite result.

Orange Judd felt so sure that private initiative was necessary to secure the legislature's speedy action favorable to the establishment of an experiment station that he went ahead independently. He secured the cooperation of the board of trustees of Wesleyan University, who offered the free use of laboratories and other facilities. Judd supplemented this by a donation of $1,000 for the expenses of the station. As a result the legislature of 1875 passed the following resolution:

> That the sum of seven hundred dollars per quarter for two years, is hereby appropriated to the University located at Middletown, Middlesex County, to be used in employing competent scientific men to carry on the appropriate work of an Agricultural Experiment Station; and the Comptroller is hereby directed to draw his order in favor of the Treasurer of the Board of Trustees of said University, for seven hundred dollars per quarter, for two years, beginning October 1, 1875: provided, the said Treasurer shall satisfy the Comptroller that such money is expended in the employment of scientific men for making the experiments and investigations contemplated in this resolution; and that the said University shall superintend such experiments, and shall provide ample laboratories and buildings therefor, free of all charge.

THE STATION AT MIDDLETOWN

Judd and A. B. Calef, as a committee of the board of trustees of Wesleyan University, undertook the organization of the station. Through the cooperation of the State Board of Agriculture and the farmers' experiment station committee, an advisory committee of leading farmers from the eight counties was appointed. Professor Atwater was made director on a part-time arrangement. W. C. Tilden became chemist, and W. Balentine and R. B. Griffin were assistants but were soon replaced by E. H. Jenkins, formerly assistant to Professor Johnson, and George Warnecke, from the Agricultural-Physiological Institute of the University of Leipzig. Arthur T. Neale, afterwards director of the Delaware Experiment Station, also gave some help.

Analysis of fertilizers was begun, and on January 13, 1876, a meeting of farmers and fertilizer manufacturers and dealers was held which recommended "that all fertilizers sold in the State should be sold under a guarantee of their composition, to be determined by analysis at the station."

A preliminary report on the work of the station was made May 1, 1876, and the first annual report was published in January 1877 (*12*, *13*). The plan of publication was to include, in the annual reports, detailed accounts of the operations of the station, and to publish brief progress or summary reports as circulars.

Analyses of 162 samples of fertilizers were given in the report for 1875–76. Some studies of the growth and composition of field crops and food materials were begun, together with investigations of the purity and vitality of seeds.

The legislature of 1877 passed an act making the station a permanent and separate State institution with the understanding that it would be located at New Haven. Therefore only one more report of the Middletown Station was issued. This included analyses of fertilizers, foods, and feeding stuffs; box experiments with fertilizers on sandy soil; observations on the quantity and composition of the roots of clover, timothy, wheat, and other plants; seed tests; farm experiments with fertilizers; and a discussion of the nutritive value of various feeding stuffs and their use in rations for farm animals. Among the persons who were associated with the work of the station recorded in this report were W. H. Jordan (p. 103), afterwards director of the Maine and New York State Experiment Stations, and C. D. Woods, afterwards director of the Maine Experiment Station.

In the work and reports of the Middletown Station a definite effort was made to put its operations on a sound scientific basis and to explain to farmers the meaning of the scientific terms necessarily used in describing the work and to show them its practical significance. The agricultural experiment station was thus shown to be primarily and fundamentally a scientific institution. This undoubtedly had a broad influence in the further development of such institutions in the United States.

After the removal of the station to New Haven, Atwater, in his private capacity, "organized and superintended an extensive series of field experiments with fertilizers in a number of States, accounts of which were printed in the annual reports of the Connecticut State Board of Agriculture for 1877 and succeeding years. He also prepared a series of about 70 articles on science applied to farming, which were published in the American Agriculturist from 1875 to 1881."

THE STATION AT NEW HAVEN

The act of March 21, 1877, provided "that for the purpose of promoting agriculture by scientific investigation and experiments, an institution is hereby established to be called and known as The Connecticut Agricultural Experiment Station" (*102*). The management of the station was committed to a board of control of eight members, one each from the State Board of Agriculture, the State Agricultural Society, the Sheffield Scientific School, and Wesleyan University, and two members appointed by the Governor, with the advice and consent of the Senate. The Governor and the director of the station were to be members ex officio. The board was to locate the station and appoint a director to have the general management and oversight of the experiments and investigations. It could use not only State funds but other funds and endowments which it might receive. It should make an annual report to the legislature. An annual appropriation of $5,000 was made to the station. Samuel W. Johnson was designated in the act to call the first meeting of the board. The first board had among its members T. S. Gold, long-

time secretary of the State Board of Agriculture; W. H. Brewer; and Orange Judd. Johnson was elected director, and the station was located in two rooms assigned to it, rent free, by the authorities of the Sheffield Scientific School. E. H. Jenkins and H. P. Armsby (*218*, *219*), who had been trained in Johnson's laboratory, were appointed chemists. Preliminary work began July 1, 1877. The first bulletin was issued August 8, 1877, and contained an analysis of a fertilizer for grass. It consisted of a single sheet and was in Johnson's handwriting, having been prepared with Edison's electric pen and duplicating press.

The first report of the station covered 6 months to the end of 1877. It contained analyses of fertilizers and feeding stuffs, seed tests, and a paper by Armsby summarizing existing knowledge regarding the relations of soil to water. Methods of fertilizer analysis had been studied with reference to their simplification.

During the next 10 years analyses of fertilizers and studies of methods of analysis constituted the chief work of this station. A revision of the fertilizer law in 1882 materially increased the work of the station relating to fertilizer control. A considerable variety of fodders and feeding stuffs were analyzed, and compilations of American analyses and coefficients of digestibility of feeding stuffs were published. Seed tests and a limited number of analyses of waters, soils, and insecticides were made.

Examinations of market milk, made by the station in 1881, were followed by an act of April 25, 1882, for milk control. In a similar way a study of the adulteration of butter was a factor in the passage in 1886 of a law which authorized the dairy commissioner to have samples of imitation butter analyzed at the station. A similar act with reference to inspection of molasses was passed the next year. In 1886 and 1887 T. B. Osborne studied methods of mechanical soil analysis.

By 1882 the station had outgrown its limited quarters at the Sheffield Scientific School, and moreover the room was needed for the work of the school. An appeal to the legislature resulted in an appropriation of $25,000 for land, buildings, and equipment for the station. About five acres were purchased at its present location, and a substantial brick laboratory was erected there. The annual appropriation for current expenses was increased to $8,000 in 1882. The amounts received from individuals for analyses gradually increased and in 1887 amounted to $3,759. The total income that year was $12,049.

Professor Atwater succeeded Orange Judd as a member of the board of control in 1880. In 1882 Dr. Jenkins became vice director of the station. In 1881 Dr. Armsby left the Connecticut station and became vice president of the Storrs Agricultural School. He was professor of agricultural chemistry at the University of Wisconsin in 1883, and director of the Pennsylvania Agricultural Experiment Station in 1887.

During the first 10 years the station issued 93 bulletins. Information regarding its work was published widely in the agricultural and general press, and there was a large correspondence with farmers and others. A valuable service was rendered in making many farmers acquainted with the actual value of fertilizers and feeding stuffs,

and in giving them useful information on many subjects outside of the experimental work of the stations. The importance of the agricultural experiment station, conducted as a scientific institution, was confirmed by the work at New Haven, and its influence extended widely throughout the United States.

CALIFORNIA EXPERIMENT STATION

E. W. Hilgard (*258*, *259*) (1833–1916) was elected professor of agriculture in the University of California on August 11, 1874. He went to the university early in 1875 and was given quarters in the basement of the building known as "Agricultural College", but which was principally occupied by scientific departments and the library of the university. The regents of the university gave him $250 for each of 2 years for "an industrial survey and experiment station." He opened an experimental chemical laboratory in the spring of 1875 and, with the consent of the secretary of the board of regents, who controlled the university grounds, began a field experiment on deep and shallow plowing for wheat grown for hay. To this was soon added an experiment with fertilizers on wheat. Dr. Hilgard realized that a better knowledge of the soils of the State would be a fundamental factor in the advancement of agriculture in California. He therefore began to collect and make mechanical and chemical analyses of soils from different localities. In April 1877 he issued a bulletin (*84*) setting forth the advantages of an agricultural and industrial survey to supplement a geological survey. To begin this survey he would make analyses of soils and publish the results with suggestions of treatment and adaptation to the culture of crops. As far as possible, field experiments would be conducted on the university grounds, and agricultural societies and individuals were urged to supplement these in their respective localities.

In his report for 1877 attention was called to the problems connected with alkali soils, and some analyses of such soils were recorded. A beginning was also made of analyses of waters, fertilizers, and sugar beets. The work of this station had made sufficiently favorable impression by 1877 to cause the legislature that year to appropriate $5,000 annually for 2 years for its maintenance; this amount was doubled in 1879. The biennial report of that year records analyses of soils, marls, clays, waters, sugar beets, watermelons, sorghums, oranges, and California wines; results of experiments with fertilizers on wheat and oats; and variety tests of sorghums and forage plants. Land for experimental purposes had been put under Dr. Hilgard's control, and a garden of economic plants had been started. An experiment on destruction of ground squirrels by the use of bisulphide of carbon was reported in a bulletin issued in April 1878. Observations on the phylloxera attacking California grapevines were also made.

The work on watermelons in 1879 put an end to the proposition to manufacture sugar from them, and the early work of the station on sorghum, sugarcane, and sugar beets helped to settle the problem of sugar manufacture in California in favor of the sugar beet. The collection and culture tests of wheat, spelt, barley, rye, oats, buckwheat, sorghum, and grasses, begun in 1878, gave much useful information regarding the varieties best adapted to the State.

Many kinds of forest trees were tested, with results which especially favored the European oak, cork oak, cork elm, black wattle, blackwood, acacia, camphor tree, mulberry, and several kinds of eucalyptus, particularly blue gum, red gum, and Australian "jarrah."

The entomological work was extended after 1880 to include problems relating to scale insects and others affecting orchard fruits and grapes. Analyses of commercial alkalies and soap were made, and a formula for whale-oil soap was devised. Among insecticide gases, hydrocyanic acid was especially studied, and a practical method for its application to citrus fruits was worked out. Experiments showed the efficiency in California of Paris green and London purple sprays against the codling moth.

Edward James Wickson (*324*) (1848–1923), a member of the editorial staff of The Pacific Rural Press, was lecturer on practical agriculture in the University of California from 1879 to 1891 and aided the station in its field work, including entomological studies.

The largest enterprises of the California Experiment Station prior to 1888 were its investigations of soils (including alkali) and waters, and in viticulture. The work on soils included chemical and mechanical analyses of large numbers of samples from different parts of the State and surveys regarding their agricultural possibilities. Dr. Hilgard's work on the Tenth United States Census from 1879 to 1883 was an important factor in supplementing the station work on soils. His census report (*85*), much of which included work by a number of assistants, was on cotton production in the United States. It comprised a description of the geology, topography, climate, soil regions, and soils of each of the cotton-producing States, including California. A special report on alkali soils and irrigation waters was included in the annual report of the College of Agriculture of the University of California for 1886.

An act for the promotion of the viticultural interests of the State, approved April 15, 1880, made it the duty of the board of regents of the university to provide instruction in viticulture and wine making and—

> to direct the Professor of Agriculture or his assistant, to make personal examinations and reports upon the different sections of the State adapted to viticulture, to examine and report upon the woods of the State procurable for cooperage and the best methods of treating the same; and to make analyses of soils, wines, brandies, and grapes at the proper request of citizens of the State; also, to prepare comprehensive analyses of the various wines and spirits produced from grapes, showing their alcoholic strength and other properties, and especially any deleterious adulterations that may be discovered.

Vine diseases were also to be studied. An appropriation of $3,000 covering 3 years was made for this work.

In 1880 a small viticultural laboratory and cellar were built, in which analytical work and experiments in wine making were conducted. When the State appropriation ceased in 1883 the university regents gave funds to continue the work. In 1884 a convention of persons interested in viticulture asked the legislature to appropriate $10,000 for a building for this work of the station. The appropriation was promptly made but unfortunately was put under the joint control of the university and the State board of viticultural commissioners. For a year these two parties contended regarding this matter but in 1886 reached an agreement to divide the fund equally

between them. This gave the station enlarged, though inadequate, quarters for the continuance of this branch of its work. From 1881 to 1888 four special reports on its viticultural work were made.

The details of the work of the California Station were published in the annual reports of the professor of agriculture to the president of the university, and in a series of one-page bulletins, of which 77 were issued from 1884 to 1887.

NORTH CAROLINA EXPERIMENT STATION

The North Carolina Agricultural Experiment Station was established under an act of March 12, 1877, creating a department of agriculture, immigration, and statistics. This act shows the influence of the University of North Carolina (*18*), which was then the land-grant institution of that State. Its president, Kemp Plummer Battle (*222*), had long been interested in the promotion of agriculture, having in 1869 revived the North Carolina Agricultural Society. Becoming impressed with the fact that the farmers were buying fertilizers unwisely and were often defrauded, he spoke at fairs and other meetings and before the legislature in advocacy of an agricultural experiment station at Chapel Hill, where the university would provide laboratory facilities. He then brought about a conference on this matter, which was attended by representatives of the grange, agricultural societies, and the university, and the State geologist, W. C. Kerr. On his motion a committee, of which he was chairman, was appointed to bring this matter to the attention of the legislature, and he wrote the report. The technical knowledge and scientific contacts of State Geologist Kerr proved valuable assets during the promotional and formative periods of the North Carolina Experiment Station.

The act provided that "The Department of Agriculture shall establish, in connection with the Chemical Laboratory of the University at Chapel Hill, an Agricultural Experiment and Fertilizer Control Station; and the Board of Trustees of the University, with the approval of the Department of Agriculture [amended to read 'the Board of Agriculture with the approval of the Board of Trustees of the University'] shall employ an Analyst skilled in agricultural chemistry."

It shall be the duty of said chemist to analyze such fertilizers and products as may be required by the Department of Agriculture, and to aid so far as practicable in suppressing fraud in the sale of commercial fertilizers.

He shall also, under the direction of said Department, carry on experiments on the nutrition and growth of plants, with a view to ascertain what fertilizers are best suited to the various crops of this State, and whether other crops may not be advantageously grown on its soils, and shall carry on such other investigations as the said Department may direct.

He shall make regular reports to the said Department of all analyses and experiments made, which shall be furnished when deemed useful to such newspapers as will publish the same (*118, p. 11, 12*).

The law also required the station to make analyses for the geological survey and the State Board of Health in cases of suspected poisoning.

The station was a branch of the department of agriculture. It had no connection with the University of North Carolina, and its officers did not participate in the work of instruction at the university.

The board of agriculture consisted of the Governor, presidents of the State university and State Agricultural Society, master of the

State Grange, State geologist, and two prominent farmers. Albert Reid Ledoux (*271*) (Nov. 2, 1852–Oct. 25, 1923) was appointed director of the station. He was born at Newport, Ky., graduated at the Columbia School of Mines in 1873, and studied chemistry at the Universities of Berlin and Göttingen, receiving from the latter the Ph. D. degree in 1875. After leaving North Carolina in 1880 he was consulting expert in mining engineering and chemistry in New York City.

Ledoux began work at Chapel Hill on April 19, 1877, and was at first "given a table in the quantitative analysis room among the students." In September 1878 the university "set apart three large rooms, with smaller rooms adjoining, for the exclusive use of the station."

The first circular of the station, issued May 7, 1877, contained explanations of the analysis and valuation of fertilizers. About a month later analyses and valuations of 23 of the 29 brands of fertilizers then sold in the State were published (*116*). Analyses of sugar beets grown in 10 counties of the State were made and, with additional explanatory matter on sugar, were published in 1878 (*117*). Analyses of soils, marls, and mineral waters were made for the geological survey. Opposition to the publication of fertilizer analyses by the station arose, and the question of the constitutionality of the fertilizer law was taken to the State supreme court, which decided in favor of the department of agriculture, thus permitting the publication of the analyses.

During the first 3 years the station made 221 analyses of fertilizers, 46 of chemicals used in composting, 130 of soils, 98 of marls, 42 of waters, and 62 of sugar beets, and 71 tests of seeds. There were also 165 analyses of minerals, ores, phosphate rocks, and mineral waters, and 45 of miscellaneous substances. Records of these analyses and much explanatory matter were published in the annual reports and bulletins. The department of agriculture was supported by a license tax paid by manufacturers of fertilizers. During the 3 years its income aggregated $80,117, of which $14,344 was used for the maintenance of the station. Dr. Ledoux ceased to be director of the station in November 1880.

The most important results of the station's work up to that time related to the use of fertilizers in North Carolina. In the year preceding the establishment of the station about 100 different brands of fertilizers were sold in the State, but the farmers had so little confidence in their value that less than 40,000 tons were sold. Very soon after fertilizer control was established, the number of brands materially decreased, but the amount sold increased and in 1880 amounted to 80,000 tons.

Charles William Dabney succeeded Ledoux as chemist and director of the station. He was born at Hampden-Sidney, Va., June 19, 1855, graduated at the college there in 1873, and afterwards studied at the Universities of Virginia and Göttingen, receiving from the latter the Ph. D. degree in 1880. He was professor of chemistry at Emory and Henry College in 1877–78 and at the University of North Carolina in 1880–81.

In 1880 the station was given 10 rooms in a refitted hotel building near the Capitol at Raleigh, which were well equipped for its work.

Up to 1888 the principal work of that station was with fertilizers. Numerous analyses were made, and the farmers were told how to purchase and mix fertilizer materials. The fertilizer resources of the State were investigated; from 1883 to 1885 its prosphate deposits were explored. Marls from 300 beds were also collected and analyzed, and pyrites deposits were examined in 1885 with reference to their value in making sulphuric acid. The chemistry of cottonseed and its products was studied, with special reference to their use as feeding stuffs or as fertilizers. Analyses of grasses, cowpeas, soybeans, and silage made from corn and from pea vines were made.

Recognizing the need of field experiments, Dr. Dabney attempted to carry on such work at Chapel Hill in 1881 but with little success. Cooperative experiments with fertilizers on the Atwater plan were then tried, and in 1884 these included tests of North Carolina superphosphates. In 1886 an experiment farm of 35 acres was established on the fair grounds near Raleigh, with Milton Whitney as farm superintendent. The work included tests of varieties of cotton, grasses, and clovers, high manuring for cotton and corn, and experiments relating to permanent meadows and pastures. Articles on the physical properties of soils were published in 1886 and 1887. The State weather service was connected with the station in 1886 and placed in charge of an observer of the United States Signal Corps. Meteorological data, including soil temperatures, were thereafter published periodically by the station.

In the first 10 years the North Carolina station published and widely distributed 56 bulletins, in addition to its detailed annual reports.

On September 1, 1887, Dabney resigned to become professor of agricultural chemistry and director of the experiment station at the University of Tennessee (and later president of the university) and was succeeded by Herbert Bemerton Battle, who had been assistant chemist of the North Carolina station from 1881.

MASSACHUSETTS EXPERIMENT STATION

Between 1875 and 1878 experimental work along a number of lines was done at the Massachusetts Agricultural College. Stockbridge continued experiments with fertilizers (*160*), published a number of formulas for various crops, and arranged for their manufacture. Goessmann continued studies of the chemical condition of the soil and soil water of salt marshes in Massachusetts and undertook experiments which led to the conclusion that drainage and thorough cultivation would gradually improve these soils and make them highly productive. He made analyses of cultivated and wild grapevines and, with S. T. Maynard, studied the effects of girdling on the growth and composition of grapes and made experiments with fertilizers on grapes.

Many substances, including waste products from various industries, were examined with reference to their value as fertilizers and feeds. The composition of dairy products and of substances used for their adulteration was investigated and analyses were made of the milk from different breeds of cows. Later experiments were made to determine the influence of different fodder plants on the quantity and quality of milk and butter from the cows to which they were fed.

Meanwhile efforts were made to secure funds with which to establish an experiment station at the college. In his report to the trustees for 1875 President Clark said that there were—

sufficient reasons for a legislative enactment requiring that such work [i. e., scientific investigations] should be constantly and systematically carried on at the State Agricultural College. * * * It is, however, indispensable for the highest success of an experiment station that its officers should have the means—

to purchase special apparatus and employ labor.

They must also have the assurance that investigations may be through a series of years.

In the report for 1876 (*68*) Charles L. Flint, secretary of the board of trustees, made a more extended argument for an experiment station, with the conclusion that—

could the college farm, or a portion of it, be organized and established as an experiment station and provided with the requisite means, it would go far to meet a great and growing public want, and do more real good for the agriculture of the present and the future of the Commonwealth than any other agency.

The experiments on the land would be supplemented by investigations in the chemical and physiological laboratories of the college. In January 1878 Stockbridge offered to give $1,000, representing royalties derived from the sale of his fertilizers, for the establishment of an experiment station. The college trustees accepted this offer and appointed a committee to organize and manage the Massachusetts Agricultural Experiment Station. This committee included President Clark, Professors Stockbridge and Goessmann, Secretary Flint, and Richard Goodman. Subjects of investigation were assigned to different members of the faculty, and they were allotted money for special apparatus and other purposes.

Stockbridge constructed a lysimeter, which was an improvement on the only other apparatus of its kind in this country, namely, that on the farm of E. L. Sturtevant (p. 97). With the aid of this apparatus the percolation of water through the soil was studied, and the loss of plant food in the drainage was determined. Soil temperatures by day and night were recorded, showing that wet soils were not any colder than dry soils; observations were made on the loss of water by the soil and plants by day and by night, leading to a new explanation of the origin of dew and the conclusion that frequent cultivation and the formation of the dust mulch conserves water in the soil (*161*).

Early Amber sorghum grown on the college farm and by farmers in the vicinity in 1878 was tested by Dr. Goessmann for the production of sugar, with the conclusion that owing to the large percentage of grape sugar in the plant in the later stages of its growth it was not suited for commercial sugar production.

Studies of the effect of different fertilizers on the composition of fruits led to the conclusion that a change in the relative proportions of the several mineral constituents affects the quantity of the organic constituents such as starch, sugar, and organic acids. For several years Goessmann and Penhallow made investigations with reference to the effects of severe pruning and the liberal use of fertilizers on peach yellows. It was believed that maintenance of the vigor of the tree would reduce the liability to this disease, and some results

seemed to indicate that muriate of potash would cure it by increasing the sugar content of the fruit.

Chemical and physical examinations of the South Carolina phosphates were made, as well as trials of their agricultural value in the raw state and after their treatment with acids.

From 1879 to 1882 the Massachusetts Agricultural College had great financial and other difficulties. For lack of funds the original station ceased to function in 1881. Meanwhile Goessmann and others interested in the station were seeking to have it made permanent through legislative action.

An act of the State legislature establishing an agricultural experiment station in connection with the Massachusetts Agricultural College at Amherst was passed May 12, 1882 (*127*). The general management of the station was committed to a board of control of seven members, including the Governor ex officio, two members each of the State Board of Agriculture and the board of trustees of the college, one member of the Massachusetts Society for Promoting Agriculture, and the president of the college.

The work of the station was to include investigations of (1) diseases of domestic animals, plants, and trees; (2) the history and habits of insects destructive to vegetation and the means of abating them; (3) the manufacture, composition, and value of fertilizers and their adaptability to soils and crops; (4) the values, under all conditions and for various purposes, of forage, grain, and root crops for feeding animals; (5) the comparative value of green and dry forage and the cost of producing and preserving it; (6) the adulteration of any article of food for men or animals; and (7) any other subjects deemed advantageous to the agriculture and horticulture of the Commonwealth.

An appropriation of $3,000 was made available before July 1, 1882, to establish, prepare, and equip the station, and $5,000 annually thereafter for its maintenance. This was increased in 1885 to $7,500.

Two rooms in the chemical department of the college served at first as the station laboratory, and the college rented to the station a dwelling house for offices and collection rooms, a barn, and 19 acres of land for experimental purposes. In 1886 additional land was assigned to the station, and a substantial brick building was erected which served for many years as the station headquarters and laboratory.

The first officers of the station, elected in November 1882, were C. A. Goessman, chemist and director; Manly Miles, superintendent of field and stock experiments; and S. T. Maynard, superintendent of horticultural experiments, microscopist, and draftsman. Dr. Miles was connected with this station only 1 year, and Professor Maynard served for about 2 years. Dr. Goessmann then actively planned and closely supervised all the work of the station, which included a large amount of analytical work in chemistry. Among the assistants at the station during its early years were a number of young men who afterwards became prominent in the experiment station movement, including W. E. Stone, H. J. Wheeler, E. W. Allen (*213*, *214*), and W. H. Beal.

The first report of the director was made January 30, 1883, and contained an outline of proposed experiments submitted to the board,

together with details of the chemical work performed since the establishment of the station. The substance of this report was published in the report of the State Board of Agriculture for 1882. Twenty-seven bulletins were published up to 1888.

The principal work of the Massachusetts Station from 1882 to 1888 has been summarized by J. B. Lindsey in the biography of Dr. Goessmann (*253*), published jointly by the corporation and associate alumni of the Massachusetts Agricultural College, from which the following statement has been prepared:

The free analyses of numerous fertilizer mixtures, agricultural chemicals, refuse materials and by-products suitable for fertilizing purposes, fodder crops, concentrated feeds, dairy products (particularly milk), and drinking waters.

The growing of soiling crops, the introduction of new soiling crops, and practical feeding experiments to test their merits. Among the plants tried which were new to the agriculture of Massachusetts, were vetch, alfalfa, serradella, horse beans, lupines, cowpeas, and soybeans.

Feeding experiments with milch cows (1885–1889), to compare the relative nutritive and economic values of English hay, corn stover, corn silage, sugar beets, and carrots.

Feeding experiments with pigs (1884–1892), to ascertain the best method of feeding, the most suitable feeds, and the cost of pork production. At first the nutritive merits of skim milk and buttermilk were compared and then the suitable proportions of corn meal and skim milk or different grain mixtures to be used in the ration for growing pigs up to about 200 pounds.

The growing of fodder corn on worn-out meadow lands partly fertilized with one or two special articles of plant food and partly without the use of any manurial matter (1883–1888). These experiments were on tenth-acre plats, which during 1883 and 1884 received no fertilizer. After that nitrate of soda, ammonium sulphate, dried blood, dissolved boneblack, muriate of potash, or sulphate of potash-magnesia was used.

Fertilizer experiments with potatoes (1884–1888), which led to an effort to discover the cause of scab.

Study of temperature conditions in the silo.

A systematic meteorological record beginning in 1883.

A beginning in 1887 of the compilation of analyses of fertilizers, cattle feeds, dairy products, and fruits, which were made at the Massachusetts Agricultural College and Experiment Station from 1868.

THE CORNELL UNIVERSITY EXPERIMENT STATION, ITHACA, N. Y.

Some experiments with field crops were begun on the farm at Cornell University by I. P. Roberts (*295*, *296*) in 1874, and a little later feeding experiments with cattle were begun; but it was not until February 1879 that an experiment station was organized. This was a voluntary organization formed by the agricultural faculty of the university and a number of agricultural organizations in the State. It was put under the general management of a board of control, consisting of the faculty and one delegate each from the State Agricultural Society, State Grange, State Dairymen's Association, and farmers' clubs of western New York, central New York, Elmira, Ithaca, and the American Institute. Officers were elected as follows: President, I. P. Roberts, professor of agriculture; director, G. C. Caldwell (*233*), professor of agricultural chemistry; treasurer, A. N. Prentiss, professor of botany; and secretary, W. R. Lazenby, professor of horticulture. These officers and G. W. Hoffman, president of the Ithaca Farmers' Club, were constituted an executive committee for the immediate management of the station. This somewhat elaborate organization did not function satisfactorily, and by 1883 the board of control was reduced to the agricultural faculty.

For the first 2 years the station had no special funds for its work, which was carried on by the faculty in addition to their duties as teachers. In 1881 an appropriation of $1,000 was made to the station by the trustees of the university, and this was increased the next year to $1,145. To this in 1883 was added $750 for the services of an analytical chemist.

The first annual report, which was issued in 1880, was printed with funds ($250) donated by Jennie McGraw. This report gave accounts of fertilizer experiments on corn (begun in 1878), feeding experiments with cows with reference to the influence of the ration on the composition of milk, testing of milk with the lactobutyrometer, and analyses of fertilizers, plaster, and sugar beets, by G. C. Caldwell; experiments on the curing of cheese, by S. M. Babcock, instructor in chemistry; effect of exposure of cream to oxygen on the quality of butter, and effect of sour whey on curd, by L. B. Arnold; notes on the bud blight insect (*Psylla pyrisuga*), cabbage insects, canker worms, and some other insects, by W. S. Barnard, assistant professor of entomology; observations on the lung plague of cattle, by James Law; experiments with self-sown seeds, by A. N. Prentiss; experiments in germination and artificial fertilization of vegetables, variety tests of peas, and culture experiments with potatoes, by W. R. Lazenby; and field experiments with wheat, oats, corn, grass, and clover, by I. P. Roberts.

Two other reports were published prior to 1888. In 1887 a number of the more important papers published in these reports were brought together in a pamphlet entitled "Studies in Practical Agriculture."

NEW JERSEY STATE EXPERIMENT STATION

In New Jersey from 1875 to 1880 the State Board of Agriculture continued to inspect and analyze fertilizers and to publish accounts of experiments with fertilizers on corn and wheat carried on at the Rutgers College farm under direction of George Hammell Cook (p. 75).

The New Jersey Agricultural Experiment Station was established under an act of March 10, 1880, and was "for the benefit of practical and scientific agriculture and for the development of our unimproved lands." It was to have "suitable branches." Its direction and management was committed to a board of directors, consisting of the Governor, the board of visitors of the State agricultural college (Rutgers College), and the president and professor of agriculture of that institution. The board was to appoint a director of the station, and chemists and other assistants "necessary to analyze soils, fertilizers and objects of agricultural interest." "A sum, not exceeding $5,000 in any one year" was appropriated in this act. This was increased to $8,000 in 1881 and to $11,000 in 1884.

The station was located in New Brunswick at Rutgers College, which offered a room for its use. A branch office, with a clerk, was established at Camden, where specimens or samples for examination were received from farmers, dealers, manufacturers, or others interested. This office was closed in 1883.

Professor Cook was appointed director and Arthur Taylor Neale (Oct. 14, 1852–Sept. 10, 1917) chemist. The latter was a graduate of

Wesleyan University in 1873, had afterwards assisted Professor Atwater in the department of chemistry there, and had been an assistant chemist at the experiment station at Halle, Germany. As the work of the station increased assistant chemists were employed. Among these there came to the station in 1882 Edward Burnett Voorhees (June 22, 1856–June 6, 1911), a native of Minebrook, N. J., who had graduated at Rutgers College in 1881 and spent the following year as assistant chemist under Professor Atwater at Wesleyan University. In 1893 he was made director of the station, a position which he held until his death in 1911. One of the assistant chemists of the station was J. L. Hills, who later became director of the Vermont Experiment Station and dean of the College of Agriculture of the University of Vermont.

Accounts of the work of the New Jersey Station prior to 1888 are given in 43 bulletins and in detailed annual reports.

The New Jersey State Station immediately began the analysis of fertilizers, using the forms and instructions prepared by Professor Johnson for the Connecticut Experiment Station. This work continued to be the largest item in the station's operations during its first 8 years. The number of brands of commercial fertilizers sold in the State steadily increased and in 1887 numbered 332. The station also analyzed many samples of farm manures and other substances used for fertilizing purposes. Field experiments with fertilizers for various crops were carried on each year at the college farm and also cooperatively by farmers in different parts of the State. Determinations of the amounts of potash, phosphoric acid, and nitrogen removed from an acre of field corn, fodder corn, clover, alfalfa, millet, and mixed hay were also made.

A great variety of fodders and feeding stuffs were analyzed, and the amount of digestible feed in corn fodder versus silage was determined.

An important enterprise of the station during this period was its investigation of sorghum as a sugar-producing plant. This was begun in 1881 as the result of the passage by the State legislature of "an act to encourage the manufacture of sugar in the State of New Jersey," and offering a bounty of $1 per ton for sorghum grown and used for sugar making and 1 cent per pound on the sorghum sugar. Variety and fertilizer tests with sorghum were made on the college farm in 1881, and from the products sugar was made in the laboratory. This work was under the direct supervision of A. T. Neale. The station also cooperated with the Rio Grande Sugar Co., which had been organized in 1881 in Cape May County to manufacture sugar and sirup from sorghum. A sugar house was built, and contracts were made with farmers to grow sorghum. In 1882 this company made 320,000 pounds of sugar and 40,000 gallons of sirup, and various improvements were made in methods of growing and handling the sorghum and in sugar-house processes, but after 6 years of operation which had not proved financially profitable, the Rio Grande Sugar Co. closed its sugar house. A small sugar factory was constructed, and this was operated in 1887 with the cooperation of the United States Department of Agriculture through H. W. Wiley, Chief of the Division of Chemistry. The station also had some part in the work of that year.

NEW YORK AGRICULTURAL EXPERIMENT STATION

The New York State Agricultural Society, the State Grange, and other farm organizations were influential in bringing about the act of June 26, 1880, establishing the New York Agricultural Experiment Station. The ruling of the comptroller that this act was defective made it necessary to secure the amended act of August 15, 1881, before the station could be put into operation. As stated in this act, the purpose of the station was to promote "agriculture in its various branches by scientific investigation and experiment" (*165*). Its general management was entrusted to a board of control of nine members named in the act and the Governor ex officio. Vacancies in the board were to be filled by the Governor for a term of 3 years. Members of the board were to receive only traveling expenses connected with attendance at meetings. An annual report to the legislature was required. An appropriation of $20,000 annually for 2 years was made in the act, and this amount was thereafter continued.

A farm of 125 acres near Geneva became the property of the station in February 1882, and work began there the following April. On this farm was a large brick dwelling of three stories and a basement, with an L. This was refitted for offices, a laboratory, and the residence of the director and three members of the staff. There was also a barn, which was remodeled, and in which a silo was built. A greenhouse and lysimeter were built and later a farm cottage. The orchard contained over 600 apple trees, as well as peach, pear, and cherry trees. Additional varieties of these and other fruits were afterwards introduced.

Connected with the station in its early years were several young men who afterward became prominent in agricultural college and experiment station work, including among others S. M. Babcock and E. F. Ladd, assistant chemists, and J. C. Arthur, botanist.

The first director of the New York Experiment Station was Edward Lewis Sturtevant (*310*, *311*) (Jan. 23, 1842–July 30, 1898). He was born at Boston, Mass., spent his boyhood at Winthrop, Me., and entered Bowdoin College in 1859, but withdrew in his senior year to enlist in the 74th Maine Volunteers, with whom he served until 1863, attaining the rank of captain. He graduated with the M. D. degree at Harvard Medical School in 1866 but did not practice medicine. With two brothers, he purchased a farm near South Framingham, Mass., in 1867. This became widely known as Waushakum Farm. Here was established a herd of Ayrshire cattle, which became noted for its milk production. This led to the organization of the North American Ayrshire Register. He also made special studies of milk secretion. By selection and culture he produced the widely known Waushakum variety of yellow flint corn and the New Christiana muskmelon. The first lysimeter in America was built on Waushakum Farm and was used in making studies on the percolation of water in soils and in drainage experiments. Accounts of the experimental work at this farm were published in agricultural journals, and particularly in the Scientific Farmer, which was established at Amherst, Mass., in 1875 and afterwards was published at Boston. Dr. Sturtevant was editor of this journal from March 1876 to October 1879. He was deeply interested in agricultural botany and particularly in

whatever related to the improvement of cultivated plants. He devoted himself to studies along this line after his retirement from experiment station work in 1887. His collection of over 500 rare and valuable botanical works is now the property of the Missouri Botanical Garden at St. Louis. Among his writings is Office of Experiment Stations Bulletin 57 on Varieties of Corn (*166*), which contains classified accounts of over 800 varieties. Sturtevant's Notes on Edible Plants, edited by U. P. Hedrick, was published in 1919 as a special and extensive part of the report of the New York Agricultural Experiment Station for that year (*80*).

Under Dr. Sturtevant's direction much attention was given at Geneva to studies of cereals and vegetables with a view to the systematic classification of varieties. He himself gave special attention to corn, but also did some work on wheat, oats, barley, and sorghum. Other lines of work included plat experiments with various field crops and vegetables, effect of immature seed on tomatoes, feeding experiments with cows to determine the effect of feed on the quantity and quality of milk, chemical studies of milk and butter, artificial digestion experiments with feeding stuffs, observations on movement of water in soils, studies of the root systems of vegetables, plant breeding, investigations on pear blight confirming its bacterial origin, spraying experiments for the control of insect pests and plant diseases, and analyses of commercial feeds and fertilizers.

A detailed record of the work of the station was published in its annual reports. From July 1882 to July 1885, 115 brief bulletins, of the nature of press bulletins, were published, and thereafter to March 1, 1887, a new series of nine bulletins, of two or three pages each, was issued.

OHIO AGRICULTURAL EXPERIMENT STATION

Experimental work began at the Ohio Agricultural and Mechanical College (since 1878 Ohio State University), at Columbus, soon after Norton S. Townshend (*313*) (Dec. 25, 1815–July 13, 1895) became professor of agriculture in 1873. He was a native of England, had come to Ohio in 1830, received the M. D. degree from the University of New York in 1840, practiced medicine in Ohio several years, served in the Ohio Legislature and in the United States Congress, and was a member of the Ohio State Board of Agriculture. From 1854 to 1858 he was associated with others in an effort to establish winter courses of lectures on agriculture for young farmers. He was also professor of agriculture at the Iowa Agricultural College from 1869 to 1873.

Prior to 1882 some experimental work was done at the agricultural college, but the college was giving so little attention to agriculture at this time that many farmers, and especially members of the Grange, thought that if an agricultural experiment station were established in Ohio it should not be under the board of trustees of the State university. This view was shared by W. R. Lazenby, who was professor of botany and horticulture in the university. Therefore the bill for an experiment station in Ohio, which was drafted with his assistance, provided for a separate institution. This bill was introduced and championed in the Ohio Legislature by Joseph H. Brigham (*228*), member of the State Senate and master of the State Grange. It became a law April 17, 1882.

Under this act the Ohio Agricultural Experiment Station was established "for the benefit of the interests of practical and scientific agriculture, and for the development of the vast agricultural resources of the State." The location, control, and general management of the station was committed to a board of control of three members appointed for one year and the Governor and director of the station ex officio. Only "actual expenses incurred while on duty" were allowed to members of this board. An annual report must be made to the Governor. The members first appointed were W. I. Chamberlain, representing the State Board of Agriculture; Nicholas Ohmer, representing the State Horticultural Society; and Emmett Mix, representing the State Grange.

The station was located at Ohio State University, whose trustees assigned to it two rooms in the new chemical building; such land on the university farm as it needed for field experiments, which at first was a field of 17 acres and some space in the fruit and vegetable gardens; a team; and implements. In exchange, the station was to give the university its farm products. For its chemical work the station was to pay part of the salary of the professor of agricultural chemistry in the university.

From 1882 to 1887 the station was supported wholly by State appropriations which averaged $4,575 per annum. The details of the station work were recorded in the annual reports, but there were also 22 brief bulletins prior to 1888.

William Rene Lazenby (Dec. 5, 1850–Dec. 15, 1916) was elected director on April 25, 1882. He was born at Bellona, N. Y., graduated with the degree of Bachelor of Agriculture at Cornell University in 1874, and was instructor and then assistant professor of botany and horticulture there from 1874 to 1881, and professor of horticulture and botany or forestry at Ohio State University until 1916. In 1886 Dr. Townshend was made director and Professor Lazenby vice director. Both men retained their professorships in the university and served the station without additional compensation.

From 1882 to 1887, inclusive, the principal work of the Ohio Experiment Station, as shown in its annual reports, was the testing of varieties of wheat, oats, corn, potatoes, small fruits, and vegetables. There were also experiments on methods of planting and fertilizing the cereals and potatoes. A large number of seed tests were also made. Observations on various kinds of weeds were reported and notes were made on a number of species of injurious insects and the means of their control. Comparisons of corn in different forms and a few other common feeding stuffs were made in experiments with cows for milk production and with pigs. A brief account of studies of swine plague was given in the report for 1886. Only a limited amount of chemical work was done during this period, consisting chiefly of analyses of feeding stuffs, milk, fertilizers, and small fruits.

EXPERIMENT STATION OF THE UNIVERSITY OF TENNESSEE

In 1879 John McLaren McBryde (*274*) (Jan. 1, 1841–Mar. 20, 1923) came to the University of Tennessee as professor of agriculture and botany. He was born at Abbeville, S. C., studied at South Carolina College and the University of Virginia, was in the military

and civil service of the Confederacy, and after the Civil War engaged in farming and scientific studies in Albemarle County, Va.

From 1879 to 1882 he made and reported experiments on the university farm at Knoxville, Tenn. (*167*). The principal work was with wheat, and included tests of varieties, and experiments on quantity of seed, time of seeding, preparation of soil, modes of culture, time of cutting, effects of preceding crops, and with fertilizers. There were also experiments in top dressing clover and grasses, and in steer feeding. Corn was grown for silage, which was stored in pit silos and tested for feeding value. There were also field tests of various kinds of sorghums, soybeans, teosinte, and milo maize.

In 1882 Professor McBryde left Tennessee to become professor and president at the South Carolina College (afterwards University of South Carolina), and finally president of the Virginia Polytechnic Institute, retiring in 1907. He was also director of the agricultural experiment stations in both these States.

His successor was John W. Glenn, who was elected professor of agriculture, horticulture, and botany, and director of the experiment station established by the trustees of the university on June 8, 1882. His term of service continued until June 1887. The station was to be "a distinct department for the promotion of the general interests of agriculture in Tennessee" (*46*). Its general management was entrusted to a committee of the board of trustees, designated "the board of control." The director was to have a chemist as assistant. Under a part-time arrangement, W. A. Noyes served in this capacity from 1883 to 1886, and was succeeded by W. E. Moses.

From 1883 the legislature required the station chemist to make the analyses of fertilizers for the State Department of Agriculture, which had charge of fertilizer inspection. For this service the station received from $700 to $1,000 per annum. Aside from this income the station had only such limited funds as the trustees of the university allotted for its work. The plan of field and feeding experiments, inaugurated by Professor McBryde, was continued, and detailed accounts were given in the biennial reports of the board of trustees of the university. There were also eight brief bulletins prior to 1887.

ALABAMA EXPERIMENT STATION

In Alabama the Agricultural and Mechanical College (now Alabama Polytechnic Institute), at Auburn, was established in 1872. Three years later some field experiments with fertilizers on cotton were made by the college on 10 acres of land in northern Alabama. Accounts of this work were published in the president's report for 1875. Experimental work at the college was also begun about this time and was somewhat broadened about 1880 under the direction of William H. Chambers, professor of agriculture. On his death, July 1, 1881, W. C. Stubbs, professor of natural science, was assigned supervision of the college farm and its experiments. The following year he made a report on Professor Chambers' experiments, with some additions. This was published in the report of the board of trustees of the college for 1880–82 (*164*) and included tests of varieties of cotton, wheat, grasses, clovers, peaches, strawberries, and grapes; fertilizer experiments with cotton, corn, and potatoes; a few analyses

of grapes and a kind of sorghum called "chicken corn"; together with compiled information on a number of subjects.

In 1883 the office of commissioner of agriculture was established by the legislature, and this official was located at the college. The same law provided for an agricultural experiment station at the college and for the publication of its work by the commissioner of agriculture. A tax of 50 cents per ton was laid on fertilizers. One-third of this tax was given to the college at Auburn for analyses of fertilizers and the maintenance of the experiment station. A farm of 226 acres near the college was purchased for the use of the station, but much of this land was unfit for experimental purposes. Only a small amount of money was available for the station work, which was carried on by college professors under a part-time arrangement.

The first director of the Alabama Station was James Stanley Newman (*283*, *284*) (Dec. 11, 1836–May 11, 1910). He was born in Orange County, Va., graduated at the University of Virginia in 1859, served in the Confederate Army during the Civil War, engaged in farming in Virginia and Georgia, and taught a private school. From 1875 to 1883 he was secretary of the Georgia Department of Agriculture. As professor of agriculture and director of the experiment station at the Alabama Agricultural and Mechanical College, he served from 1883 to 1892, and then held similar positions at Clemson College in South Carolina until 1894. For the next three years he engaged in farming but returned to Clemson College in 1897 as professor of agriculture and vice director of the experiment station, continuing in these positions until his retirement in 1905.

The chemist of the Alabama Station from 1883 to 1885 was William Carter Stubbs (*308*, *309*) (Dec. 7, 1843–July 7, 1924). He was born in Gloucester County, Va., studied at William and Mary College, graduated at Randolph-Macon College in 1862, and later studied at the University of Virginia. He was professor of natural science in the East Alabama College from 1868 to 1872 and held a similar position in its successor, the Agricultural and Mechanical College of Alabama, until 1885. There he was also State chemist and made the analyses of fertilizers under the fertilizer-control act. He also made special studies on the composition of the phosphates and greensands of Alabama and on the chemistry of sugarcane. At a meeting of farmers in August 1884 he moved that a State agricultural society be formed. This was done, and Professor Newman was its first president.

The work of the station at Auburn, prior to 1888, consisted largely of variety tests of field crops, orchard fruits, grapes, and vegetables. Experiments with varieties of corn and cotton and with fertilizers for these crops were leading enterprises. The root development of these crops was also studied. Intensive inbreeding of some purebred Jersey cattle for 4 years was the only experiment with animals.

In 1885 the legislature established a branch experiment station at Uniontown, in that part of the prairie section of Alabama known as the Canebrake, which has peculiar calcareous soils.

Reports of the station work during this period were included in three series of bulletins issued by the commissioner of agriculture. Of the first series of ten bulletins from October 1883 to August 1885 only five dealt with experiments. The others gave general informa-

tion and analytical data on fertilizers and some compiled articles on other agricultural subjects. The second series of nine bulletins, which closed in February 1887, was of a similar nature. The eight bulletins in the third series up to the end of 1887 were more definitely station publications, all of which recorded experiments, including some at the Canebrake branch station.

WISCONSIN AGRICULTURAL EXPERIMENT STATION

At the University of Wisconsin from 1875 to 1880 William W. Daniells continued to make and report field experiments with varieties of cereals and potatoes (p. 82). There were also some experiments on depths of plowing and with fertilizer for corn. In 1880 Professor Daniells was transferred to the chair of chemistry in the university. That year William Arnon Henry was appointed professor of botany and agriculture, this title being changed to professor of agriculture in 1883. He was born at Norwalk, Ohio, June 16, 1850, studied at Ohio Wesleyan University, was principal of high schools in Indiana and Colorado, and graduated with the B. Agr. Sci. degree at Cornell University in 1880. When Professor Henry began work at the University of Wisconsin in 1881 he had not even a single room in any of the college buildings, but did all his work at the farm.

The Legislature of Wisconsin in 1881 made an appropriation of $4,000 for experiments in the manufacture of sirup and sugar from Amber cane and for the silage of fodders, and a smaller amount was granted for these purposes the next year. Special reports (*81*, *82*) were made on this work. A small building was erected on the university farm and equipped with apparatus and machinery for sugar making. The first year Early Amber sorghum was grown on 4 acres, and several barrels of sirup and about 1,000 pounds of sugar were made. The second year 26 varieties of sorghum were grown, the effect of different fertilizers on the quantity and quality of the crop was tested, and additional sirup and sugar were made.

In his annual message to the legislature in 1883 Governor Rusk recommended the establishment of an agricultural experiment station at the university. The legislature approved this in an act of April 2, 1883, increasing the appropriation for the university but assigning no definite amount to the station. The station was organized October 1, 1883, under the general control of the farm committee of the board of trustees of the university and under the immediate joint direction of W. A. Henry, William Trelease, and H. P. Armsby. In 1886 Henry was director and Armsby associate director. Trelease left Wisconsin in 1885 to become professor of botany at Washington University and in 1889 director of the Missouri Botanical Garden at St. Louis. He was succeeded by A. B. Seymour as botanist of the station, 1885–86.

An act of April 3, 1883, provided for printing 12,000 copies of the annual report of the agricultural department, and this was amended April 11, 1885, to include 18,000 copies of the report of the experiment station, which must not exceed 200 pages.

The station was assigned an office, chemical and botanical laboratories, and an herbarium in South Hall of the university. These quarters were enlarged in 1884, and the building became known as Agricultural Hall. Under Henry's guidance the station work was

organized (*210*) to aid in the development of a system of farming in Wisconsin based on dairy husbandry. While he continued tests of varieties of cereals and potatoes, his principal enterprises were feeding experiments with dairy cows, calves, steers, and pigs. Various feeding stuffs, rations, and methods of feeding were tested; cooked and uncooked feeds were compared; the practice of having pigs follow steers was investigated; and there were special experiments in feeding pigs for fat or lean meat. Different systems of setting milk for cream were compared, churns were tested, and the amount of water in butter was determined. Special attention was given to chemical work and feeding experiments which involved studies of the composition of feeding stuffs, milk, and butter, and of problems relating to nutritive ratios and feeding standards. Fundamental investigations were made of the effect on the quantity and quality of milk production of varying proportions of protein to carbohydrates and fat in the ration. Onion mold, apple scab and leaf blight, and a spot disease of strawberry leaves were studied, and tables showing when leaves of forest, fruit, and other trees and shrubs appear and fall were prepared.

MAINE FERTILIZER CONTROL AND AGRICULTURAL EXPERIMENT STATION

At the Maine State College at Orono, the field and feeding experiments previously mentioned (p. 79) were continued from 1875 until 1879 in charge of J. R. Farrington. He was succeeded as instructor in agriculture by W. H. Jordan, who for 2 years carried on experiments with fertilizers on corn and potatoes, methods of planting potatoes, and the best time for cutting grass. From 1882 to 1885 Walter Balentine, as professor of agriculture, and G. M. Gowell, as farm superintendent, conducted experiments in feeding pigs and dairy cows, and with fertilizers on beans, potatoes, barley, timothy, and clover.

An act of March 3, 1885, provided "that for the purpose of protection from frauds in commercial fertilizers, and from adulterations in foods, feeds, and seeds, and for the purpose of promoting agriculture by scientific investigation and experiment, the Maine Fertilizer Control and Agricultural Experiment Station is hereby established in connection with the State College of Agriculture and Mechanic Arts.

The management of the station was committed to a board consisting of the professor of agriculture of the college and the secretary of the State Board of Agriculture ex officio, together with three other members to be appointed by the Governor for terms of 3 years. The board was to appoint a director and assistants, publish bulletins, and make an annual report to the Governor. An annual appropriation of $5,000 was made for the support of the station. The director of the station, or his representative, was required to collect samples of commercial fertilizers offered for sale in the State and to have them analyzed at the station.

A laboratory and office for the station were provided in college buildings. Professor Balentine served as acting director until July 1, 1885. From that time until 1896 Whitman Howard Jordan was director. He was born at Raymond, Maine, October 27, 1851, graduated at Maine State College in 1876, studied under Professor At-

water at Wesleyan University, and received the degree of Master of Science at Cornell University in 1878. Then he was assistant at the Connecticut Agricultural Experiment Station, instructor at the Maine State College in 1879 and 1880, and professor of agricultural chemistry at the Pennsylvania State College from 1881 to 1885. After leaving Maine in 1896, he was director of the New York Agricultural Experiment Station, at Geneva, until 1921. James M. Bartlett and L. H. Merrill were the first assistants at the Maine Station, and Gilbert M. Gowell was superintendent of field and feeding experiments.

The first bulletin was issued May 18, 1885, and there were 20 others up to the end of 1887. The details of the station work were published in annual reports. The first report was for April, May, and June 1885, and included only analyses of fertilizers. During the first 3 years, in addition to the fertilizer analyses, the station made feeding experiments with dairy cows, steers, and pigs to compare corn in various forms with cottonseed meal, and other experiments to determine the digestibility of timothy hay, corn meal, cottonseed meal, oats, straw, and potatoes. Different kinds of feeding stuffs, and milk, cream, and skim milk produced under different conditions were analyzed. Fertilizer experiments were also made at the station and by eight farmers in different localities, and variety tests of potatoes, oats, and barley were carried on.

LOUISIANA EXPERIMENT STATIONS

In 1884 the Legislature of Louisiana passed an act to establish agricultural experiment stations in connection with the Louisiana State University and Agricultural and Mechanical College, and this institution was made the beneficiary of the bill for Federal aid to State experiment stations, then pending in Congress, but which did not become a law until March 2, 1887 (Hatch Act). Meanwhile, an experiment station was established in Louisiana by sugar planters and maintained wholly with private funds for about three years.

The Sugar Experiment Station was established in September 1885 on a plantation at Kenner, a few miles north of New Orleans (later at Audubon Park, New Orleans). On this place were a dwelling house, stables, and a small sugar house. A chemical laboratory was fitted up there. The objects of this station as stated in its first bulletin were (1) to test the growing of more cane upon a given area, (2) to study the political economy of sugarcane, (3) to test scientifically and practically the various methods of making sugar, and (4) to disseminate information among the subscribers of the station and to advance the sugar interest of Louisiana. A subsidiary object was to conduct experiments "with the cognate crops—corn, oats, peas, and perhaps rice." The station was organized and managed under the general direction of the executive committee of the Louisiana Sugar Planters Association. W. C. Stubbs was called from the Alabama Agricultural and Mechanical College to be director of this station.

In February 1886 the State Bureau of Agriculture organized the State Experiment Station and located it at Baton Rouge. A State fertilizer law, which went into effect September 1, 1886, provided for fertilizer control by the commissioner of agriculture, who was authorized to make contracts with the two experiment stations to

employ an official chemist and to carry on experimental work at these stations, and to pay for this work out of State funds. Dr. Stubbs was made State chemist and director of both stations. Reports on the work of both of these stations were published by the State commissioner of agriculture in 11 bulletins issued up to 1888.

At the Sugar Experiment Station during the first 2 years the field experiments with sugarcane included tests of varieties, fertilizers, and planting different parts of the cane, with or without suckers. Analyses were made of the cane and of the soils. There was also considerable work in the sugar house, especially on different methods of purifying the juice, accompanied by careful chemical control of the materials used and the results. Several varieties of sorghum were grown and analyzed with reference to the sucrose content of the juice and the making of sugar therefrom. Experiments with fertilizers for and on time of planting of oats were made, as well as variety and fertilizer experiments on corn. At the State Experiment Station variety and fertilizer experiments with oats, cotton, and potatoes were carried on. The fertilizer analyses required by the control law were also made and published.

KENTUCKY AGRICULTURAL EXPERIMENT STATION

The Kentucky Agricultural Experiment Station had its origin in a resolution of the executive committee of the board of trustees of the Kentucky Agricultural and Mechanical College, passed in September 1885, by which it was determined to establish an agricultural experiment station in connection with the college, the professors of natural science and agriculture being expected to take part in the work as far as consistent with their college duties. The executive committee of the college at this time was the governing board of the station. At a meeting of the executive committee on September 25, 1885, M. A. Scovell (Feb. 26, 1855–Aug. 15, 1912), at that time in the employ of the United States Department of Agriculture as a special agent in sugar experiments, was elected director of the proposed experiment station and assumed his duties in November of the same year. He was born at Broadway, N. J., graduated at the University of Illinois in 1875, and served there as assistant in chemistry, and instructor, assistant professor, and professor of agricultural chemistry until 1882, when he became chemist and manager of the Kansas Sugar Co. at Sterling, Kans. He was director of the Kentucky Station until his death. One large room in the basement of the college building was assigned to the station, and this was made to serve as office and chemical laboratory.

The first publication of the station was a circular issued December 4, 1885, announcing its organization; and the first bulletin, issued December 23, 1885, gave an account of an experiment with fertilizers on tobacco made in the previous summer by the professor of agriculture. The first chemical work actually done in the laboratory of the station was the analysis of some corn fodder, the results of which were published January 4, 1886, as Bulletin No. 2 of the station.

The resources of the station were at first exceedingly limited, but early in 1886 the State Legislature passed an act, approved April 13, by which the law regulating the sale of commercial fertilizers in the

State was so changed as to put the experiment station in charge of fertilizer control; and all the fees pertaining thereto were required to be paid into the treasury of the college, to be expended in meeting the legitimate expenses of the station, including analyses of fertilizers and experimental work. In this act the station was formally recognized as the Kentucky Agricultural Experiment Station.

In the spring of 1886 the tillable land of the college, about 12 acres, was assigned to the use of the station for field experiments, and a series of variety and fertilizer tests with field crops (including clover, wheat, and potatoes) was begun. In June of that year the working force of the station was increased by the election of Alfred M. Peter as assistant chemist. Before this time the director was the only person whose time was devoted exclusively to the work of the station.

VERMONT STATE AGRICULTURAL EXPERIMENT STATION

In Vermont an act of November 24, 1886, provided that—

> for the promotion of scientific and practical agriculture and for preventing frauds and adulterations in commercial fertilizers, foods, feeding stuffs, seeds, and commercial products, there is hereby established a State agricultural experiment station in connection with and under the control of the University of Vermont and State Agricultural College (*44*).

The general oversight of the station was committed to a board of control, consisting of two members of the board of trustees of the university and its president, ex officio. In the law the station was especially charged with investigations in entomology, introduction of new agricultural industries, new fodder plants, and new feeding stuffs, and in the nutrition and growth of plants. The station was to make analyses of fertilizers, soils, feeding stuffs, milk, butter, oleomargarine and other butter substitutes, and drinking waters, and to carry on the fertilizer control under the act of November 29, 1882. An appropriation of $3,500 annually was made for the maintenance of the station. The first director was Wells Woodbridge Cooke (Jan. 25, 1858–Mar. 30, 1916). He was born at Haydenville, Mass., graduated at Ripon College in Wisconsin in 1879, and was a graduate student in chemistry at the University of Vermont in 1885. In January 1886 he became lecturer in agriculture at this university and a few months later professor of agriculture. On leaving Vermont in 1893, he was professor of agriculture and director of the experiment station at the Colorado Agricultural College until 1900 and then was on the staff of the Bureau of Biological Survey at Washington, D. C., until his death.

The sampling and analysis of commercial fertilizers necessarily occupied a large part of the station's attention during its first year. Analyses were also made of corn, silage, teosinte, corn meal, cottonseed meal, buckwheat middlings and bran, wheat bran, gluten meal and hay from timothy, oats, alsike clover, cowpeas, serradella, vetch, yellow lupine and alfalfa, and drinking waters.

The station had no farm, but cooperated with a few farmers in tests of alfalfa, cowpeas, fertilizers, and the use of bone meal in a ration for a dairy cow. Compiled information on the composition, digestibility, and fertilizing value of feeding stuffs, on feeding standards, and on the compounding of rations was also published. The details of the station work were included in the annual report for 1887, and four short bulletins were also published that year.

AGRICULTURAL EXPERIMENTS IN STATES NOT HAVING EXPERIMENT STATIONS, 1875–88

COLORADO

In Colorado a State Board of Agriculture was established under an act of February 27, 1887 (*162*, *163*, *198*). This act provided that the board should establish and manage "The State Agricultural College", with a farm. "All agricultural operations on the farm shall be carried on experimentally, and for the instruction of the students, and with a view to the improvement of the science of agriculture in the State of Colorado." Accounts of experiments at the college were to be included in the annual reports of the board. The college was located on an irrigated farm at Fort Collins and was opened for students in September 1879. Experiments with field crops were begun in March of that year and included principally tests of varieties. Special attention was given to wheat, and there were some experiments in crossing varieties. Other crops grown experimentally were corn, barley, rye, oats, buckwheat, sorghums, kafir, millet, broomcorn, grasses, red clover, potatoes, flax, and hemp. This work was in charge of A. E. Blount, as professor of agriculture.

In horticulture the planting of an orchard was begun in 1878. During the next 10 years a considerable number of varieties of apples, pears, and plums were grown. There were also tests of varieties of small fruits and vegetables. Plantations of different kinds of forest trees, which in 1884 numbered over 12,000, were made at the college. In 1886 and 1887 experiments in irrigation, with special reference to duty of water, were made by Elwood Mead, as professor of physics and engineering.

Besides the accounts of experiments at the college in the annual reports of the State Board of Agriculture in 1880 to 1887, there were pamphlets entitled "Experiments and Public Work of State Agricultural College, 1884" (*34*) and "Experimental Work of the Horticultural Department of the Colorado Agricultural College, 1886." In 1887 three bulletins of the college were issued, two of which recorded experiments. A History of Agriculture in Colorado was published in 1926 (*158*).

ILLINOIS

At the Illinois Industrial University, George Espy Morrow (*279*) (Oct. 19, 1840–Mar. 26, 1900) was appointed professor of agriculture June 7, 1876. He was born in Warren County, Ohio, educated at Mainsville Academy, served about 2 years in the Union Army during the Civil War, studied law at the University of Michigan, and was editor of Western Rural, in Detroit, and Western Farmer, in Madison, Wis. After leaving the University of Illinois in 1894 he was president of the Oklahoma Agricultural and Mechanical College until 1899, when he retired to his farm at Paxton, Ill.

He increased and systematized the experimental work on the farm of the Illinois University, giving special attention to problems of corn production, including varieties, methods of planting, and cultivation, fertilizers, and the place of corn in rotation of crops. In this and other agricultural work he had the assistance of Thomas Forsyth Hunt, who graduated at the university in 1884 and was assistant to the Illinois State entomologist the following year. From

1886 to 1888 Hunt reported field experiments with potatoes, on the relation of soil moisture to tile drainage, and on cultivation of crops. He also conducted feeding experiments with pigs and calves to determine the place of skim milk in rations in which corn or corn meal were also used, and with steers fed a ration in which grass was supplemented with grain.

Henry A. Weber was professor of chemistry and in work relating to agriculture was assisted by M. A. Scovell (p. 105), who became professor of agricultural chemistry in 1880. Soil analyses were made, and from 1880 to 1882 an investigation of sorghum was conducted, and included analyses of the plants at different stages of growth, changes in composition after harvesting, effect of different kinds of soil and of freshly manured soil on the sugar content, and experiments in sugar making. Professor Weber was succeeded by William McMurtrie (p. 50), who reported in 1884 on the chemistry of the hog.

Professor Burrill (p. 81) continued studies on bacteria, with special reference to their relation to diseases of plants and their insect vectors, and made reports on inoculation experiments with fire blight of pears and apples, on the parasitic fungi of Illinois, on silk culture, and on the development of the forest plantation at the university.

Accounts of the experimental work at the university from 1875 to 1888 were published in the biennial reports of the board of trustees.

INDIANA

Purdue University, at LaFayette, Ind., is the land-grant institution of that State and was opened for students September 16, 1874. In its first faculty was Harvey W. Wiley (p. 57), as professor of chemistry, who continued in that position until 1883. In 1876 he reported analyses of the soils of the college farm and the milk of the farm cows. He was interested in making sirup and sugar from sorghum and made analyses and special studies on this subject. In 1881 a fertilizer-control act was passed, under which Dr. Wiley was made State chemist. Thereafter, reports of the analyses of fertilizers, made under this law, were included in the annual reports of the university. In 1883 Dr. Wiley was succeeded by Robert B. Warder, as both professor of chemistry and State chemist.

In 1876 Emerson E. White became president of the university and in his inaugural address and his report for 1878 recommended that from 5 to 10 acres of the college farm should be made an agricultural laboratory under the general management of a committee of the board of trustees, where experiments would be conducted under direction of the professor of agriculture. That year experiments in sowing different amounts of wheat per acre were reported.

In September 1878 Charles L. Ingersoll (*264*) (Nov. 1, 1844–Dec. 8, 1895), a native of Perry, N. Y., a graduate of the Michigan Agricultural College in 1874 and thereafter assistant and professor of agriculture there, became professor of agriculture at Purdue University. After leaving this institution in 1882 he was president of the Colorado Agricultural College, and from 1888 to 1891 he was also director of the Colorado Experiment Station.

Between 1879 and 1882 tests were made of varieties of wheat, corn, oats, sorghum, grasses, clovers, potatoes, grapes, raspberries, and

strawberries. Fertilizer experiments with wheat, corn, oats, and grass were also made.

Professor Ingersoll was succeeded by William Carroll Latta, born at Union Mills, Ind., March 9, 1850, a graduate of Michigan Agricultural College in 1877, and thereafter an assistant at that college in field and feeding experiments. At Purdue University he was instructor the first year and then professor of agriculture and horticulture and farm superintendent. The general plan of field experiments was continued with more attention to methods of planting and cultivation.

In 1885 a separate professorship of horticulture and entomology was established and put in charge of James Troop, who was born at Bennington, N. Y., March 14, 1853, and graduated at the Michigan Agricultural College in 1878. F. M. Webster, a special agent of the United States Bureau of Entomology, was also doing work in economic entomology in connection with Purdue University.

The experimental work in agriculture at Purdue University, prior to 1888, is described in the annual reports of the university, but some of the more important work is also recorded in a series of 12 bulletins begun in January 1885. These include accounts of experiments with wheat, oats, corn, and fertilizers, by Professor Latta; experiments with varieties of orchard and small fruits, by Professor Troop; and notes on the Hessian fly and other insects affecting wheat, by Webster.

IOWA

At the Iowa State Agricultural College, I. P. Roberts (p. 94) was succeeded in 1873 by Millikan Stalker. At first he was assistant professor of agriculture, but when in 1876 it was decided to have veterinary science taught at this college he studied this subject at veterinary schools in New York City and Toronto, Canada, and was made professor of agriculture and veterinary science at the Iowa State College in 1877. In 1879 he became professor of veterinary science alone. In the biennial report of this college for 1874–75 he reported a feeding experiment with pigs, in which dry and cooked corn was compared with corn meal in the ration. There were also experiments with varieties of corn and on methods of planting, manuring, and cultivating this crop. Gypsum was applied on grasses, clover, and corn.

Henry H. McAfee became professor of horticulture and forestry on November 12, 1873. He had been prominent in the Northern and State Horticultural Societies in Illinois. Plantings of orchard fruits, grapes, small fruits, vegetables, and forest trees were made. In the biennial report of the college for 1874–75 brief accounts of 47 experiments are given. Among these were tests of varieties of potatoes, methods of planting sweetpotatoes, bud and root pruning of tomatoes, the transplanting of trees, and experiments in growing green ash and honeylocust.

In 1876 Joseph Lancaster Budd (*230*) (July 3, 1935–Dec. 20, 1904) became professor of horticulture and forestry. He was born near Peekskill, N. Y., and was educated at Monticello Normal Institute, with a partial course at Union College. In 1857 he went to Rockford, Ill., where he taught in secondary schools. He then engaged successfully in the nursery business at Wheaton, Ill., and Shellsburg, Iowa.

In 1873 he was elected secretary of the Iowa State Horticultural Society and in that capacity issued 21 annual volumes. He was in active service at the Iowa State College for 22 years, after which he was professor emeritus until his death. He was especially interested in determining the varieties of horticultural and forest plants adapted to Iowa. To this end he enlarged the plantations at the college and systematically followed up the tests of varieties. In 1882 the legislature made a special appropriation of $1,500 annually for experiments in agriculture and horticulture. That year Professor Budd went to northern Europe, especially Russia, and obtained a large number of varieties of apples, together with some pears, cherries, plums, apricots, peaches, roses, and forest trees. The work with Russian apples in Iowa and some other States attracted wide attention.

Seaman Asahel Knapp (*270*) (1833–1911) went to the Iowa State College as professor of agriculture in 1880. He was born at Schroon, N. Y., graduated at Union College in 1856, and 10 years later moved to a farm near Vinton, Iowa, where he became a breeder of Berkshire hogs and Shorthorn cattle. In 1883–84 he was president of Iowa State College and then dean of agriculture until 1886.

Reports on the experimental work of this college were published in a series of special bulletins between 1883 and 1888. Accounts of the agricultural work were given in the bulletins for 1883 and 1886. These included the milk records of cows and records of growth of calves as related to their ancestry; experiments in setting milk for cream; churning sweet versus sour milk; feeding pigs on various combinations of corn, corn meal, oil meal, bran, and skim milk; tests of many kinds of grasses, clovers, and alfalfa and varieties of potatoes and oats.

In the department of botany Professor Bessey (p. 115) made studies of injurious fungi in Iowa, some of which were published in the report of the college for 1876–77. He was succeeded in 1885 by Byron David Halsted (June 7, 1852–Aug. 28, 1918), who was born at Venice, N. Y., graduated at the Michigan Agricultural College in 1871, received the D. Sc. degree at Harvard University in 1878, specializing in cryptogamic botany, and was managing editor of the American Agriculturist from 1880 to 1885. He left Iowa in 1889 to spend the rest of his life as professor of botany at Rutgers College and botanist of the New Jersey Agricultural College Experiment Station. In November 1886 he published a bulletin at the Iowa State College containing an account of germination tests, observation on weeds, the times of blooming of spring and summer plants, notes on fungi, and a partial list of Iowa powdery mildews. Another bulletin in February 1888 gave additional notes on germination tests and fungi.

In the department of zoology and entomology Herbert Osborn, a native of Lafayette, Wis., and graduate of the Iowa State College in 1879, was assistant 1880–83, assistant professor 1883–85, and professor 1885–98, and after that time held a similar position at Ohio State University. In January 1888 he published a bulletin at the Iowa State College on the chinch bug in Iowa.

KANSAS

At the Kansas State Agricultural College, Edward Mason Shelton (*303*) was elected professor of agriculture in 1874. He was born in Huntingdonshire, England, August 7, 1846; came to New York in 1855 and to Michigan in 1860; graduated at the Michigan Agricultural College in 1871; was superintendent of the experiment farm at Tokio, Japan, for a year; and lived for a time at Greeley, Colo. On leaving Kansas in 1890 he became agricultural adviser to the Government of Queensland, Australia, and the first principal of the Queensland Agricultural College. In 1897 he returned to the United States and settled in the State of Washington. He died in 1928.

Under his direction the field experiments at the Kansas College up to 1888 included tests of varieties of wheat, corn, barley, oats, millet, sorghum, alfalfa, and many kinds of grasses; experiments in harrowing wheat, deep and shallow plowing, manuring, subsoiling, thorough cultivation and thick seeding of corn, and in shrinkage of wheat and corn in the bin. There were also experiments in feeding pigs in cold weather in warm versus open-air pens, on milk, corn-and-cob meal, cooked versus raw corn, and alfalfa pasture; feeding steers on corn meal versus corn-and-cob meal, and milk cows on warm versus cold drinking water.

In horticulture the foundation of experiments with varieties of fruits, forest trees, and ornamental plants was laid by Elbridge Gale (Dec. 25, 1824–November 1907), a native of Bennington, Vt., who had studied at Brown University and entered the Baptist ministry, serving churches in Pavillion, Ill., and Manhattan, Kans., where he also established a nursery for forest and fruit trees and other plants on land which later formed a part of the college grounds. He was elected professor of horticulture at the Kansas State Agricultural College in 1870 and served in that capacity until 1878. From 1884 he lived at Magnolia, Fla.

In 1879 Edwin Alonzo Popenoe (July 1, 1853–Nov. 13, 1913) was elected professor of botany and horticulture. He was born in Montgomery County, Ohio, graduated at Washburn College, Topeka, Kans., and engaged in school work. At the Kansas State Agricultural College he taught botany, horticulture, zoology, and entomology, but from 1899 to 1908 he was professor of zoology. Under his direction up to 1888 the experimental work in horticulture consisted chiefly of tests of a large number of varieties of apples, pears, peaches, plums, apricots, grapes, strawberries and other small fruits, forest trees, and ornamental shrubs.

MICHIGAN

At the Michigan Agricultural College a considerable number of experiments were carried on during the 10 years ended in 1885. Many of these were in continuation of work previously reported (p. 74).

In the department of chemistry R. C. Kedzie (p. 74) made a study of the wheat berry at different stages of growth and analyses of soils, wheat, and corn. In 1881 the legislature appropriated $1,000 for experiments with silage, culture of Amber sorghum, and varieties of grain and beets. In cooperation with the department of agriculture Dr. Kedzie had a silo constructed and made chemical studies of the

silage stored there. In a similar way he worked with sorghum with reference to sugar production.

In the department of botany and horticulture W. J. Beal (p. 75) tested many varieties of orchard and small fruits and vegetables, and various species of grasses and forest and ornamental trees and shrubs. He also tested seeds and made experiments in selection and crossing of wheat, corn, and beans and other vegetables. In the department of agriculture experiments were carried on by C. L. Ingersoll until 1879 and later by his successor, Samuel Johnson. Johnson was born at Springfield, N. Y., July 7, 1839, was educated at Cazenovia Seminary, moved to Dowagiac, Mich., in 1862, and engaged in farming. His service at the Michigan Agricultural College ended in 1889, when he returned to his farm. The field work included tests of varieties of wheat, oats, corn, sorghum, sugar beets, and potatoes, and experiments with fertilizers, methods of planting and cultivation, and root pruning. There were also feeding experiments with steers and on the milk production of cows.

In the department of zoology and entomology A. J. Cook gave special attention to problems of apiculture and made experiments with arsenites for the control of the codling moth and with other insecticides for various purposes.

The year 1885 was an important one in the history of the Michigan Agricultural College, with special reference to its scientific and experimental work. The long term of President T. C. Abbot came to an end, and he was succeeded by Edwin Willits, who was a prominent promoter of the Federal experiment station act then pending in Congress. A State act of March 20, 1885, largely due to the work of Dr. Kedzie, provided for fertilizer control under the State Board of Agriculture and thus brought the analytical work required by this act into the department of chemistry of the college. An act of May 11, 1885, authorized the State Board of Agriculture to issue bulletins on the results of experiments at the college, along with other information useful to farmers and horticulturists. It required that—

> the several professors of chemistry, zoology, botany, agriculture, horticulture, and veterinary science shall at least twice a year, not including the president and other professors, prepare for publication an article embracing such facts as they may deem of public importance.

This act had the effect of making the experimental work of the college a more systematic and important part of its program and brought the results of this work definitely to the attention of the agricultural people of the State. This series of publications included 31 bulletins prior to 1888.

Dr. Kedzie contributed bulletins giving his analyses of marls in the State, and of wood ashes from various sources, as well as the fertilizer control analyses, and an article on Early Amber sorghum as a forage crop. Dr. Beal recorded his experiments on the vitality of seeds of different plants buried in the soil, tests of mixed lawngrass seed, and notes on grasses and forest trees. Professor Cook wrote on the wintering of bees and on the carpet beetle. Professor Johnson recorded tests of varieties of wheat and potatoes, and experiments with different amounts of seed for these crops, and with cattle of different breeds to test the feeding qualities of individual animals. Edward A. A. Grange, a graduate of the Ontario Veterinary College,

who had become professor of veterinary science in 1883, described his experience in the use of a cold wet pack in the treatment of milk fever in cows and his observations on a disease affecting the eyes of sheep.

Liberty Hyde Bailey, who had graduated at the Michigan Agricultural College in 1882 and had been an assistant of Asa Gray at Harvard University, became professor of horticulture in 1885 and contributed articles in this series of bulletins, which described his tests of varieties of orchard and small fruits and ornamental trees and shrubs. Louis Knapper, florist at the college, wrote a bulletin on seed tests.

MINNESOTA

At the University of Minnesota, Charles Y. Lacy, as assistant professor of agriculture, continued experiments on the farm near the campus from 1876 to 1879. These included principally tests of varieties of wheat, oats, corn, barley, rye, potatoes, and garden vegetables, and fertilizer experiments on wheat, corn, and potatoes. He was succeeded in January 1881 by Edward D. Porter as professor of theoretical and practical agriculture. Dr. Porter was born at Tinmouth, Vt., August 12, 1829, graduated at the University of Pennsylvania in 1851, and thereafter for 30 years was connected with the Delaware College at Newark, Del., where he taught sciences and mathematics, and after that institution became a land-grant college in 1867 was also professor of agriculture. He was made director of the Minnesota Agricultural Experiment Station when it was organized in 1888. After leaving Minnesota in 1889, he was professor of agriculture and director of the experiment station at the University of Missouri.

On Dr. Porter's recommendation in 1882 the farm near the campus was sold, and another farm of 155 acres, a mile and a half away, was purchased. Here, prior to 1888, tests of varieties of wheat, oats, barley, corn, peas, beans, potatoes, grasses, apples, pears, grapes, and small fruits were made. Special attention was given to varieties of Russian apples. Two silos were built and filled with silage corn in 1886. There was also a feeding experiment with steers in which wheat bran formed a part of the ration.

In 1878 the State Legislature authorized the purchase of a tract of land (117 acres) on the shores of Lake Minnetonka to be used for experiments in growing varieties of fruits adapted to local climatic conditions. This farm was put under the direction of the board of regents of the university. Varieties of apples, pears, peaches, grapes, strawberries, raspberries, and blackberries were planted there, but this enterprise was not successful and came to an end in 1888.

An act of March 7, 1885, made it the duty of the board of regents, as soon as practicable, to establish at the university "an agricultural experiment station for the purposes of promoting agriculture in its various branches by scientific investigations and experiments," of which the professor of agriculture should be general superintendent. No funds were appropriated for this purpose, and therefore the station did not come into actual existence until after the passage of the Hatch Act. The same year a State act was passed authorizing the board of regents to test hardy varieties of forest trees in connection with the State School for Orphans at Owatonna, but no funds were provided for this work at this time.

MISSISSIPPI

At the Mississippi Agricultural and Mechanical College, Frank A. Gulley was professor of agriculture from 1880 to 1888. He was born at Dearborn, Mich., April 24, 1851, and graduated at the Michigan Agricultural College in 1880. After leaving Mississippi he was director of the Texas Agricultural Experiment Station and afterwards of the Arizona Station. On the farm of the Mississippi College he made tests of varieties of cotton, corn, and grasses and other forage crops; fertilizer experiments with cotton and corn; and a few feeding experiments with steers, in which cottonseed or cottonseed meal was combined with hay, straw, or silage. In cooperation with John A. Myers (*282*) (May 29, 1853–Apr. 8, 1901), professor of chemistry, he made an intensive study of the root systems of lespedeza, cowpeas, Bermuda grass, and clover. Analyses of these plants were made by Dr. Myers, who also, as State chemist, made the analyses connected with the fertilizer control. Myers was born in West Virginia, studied science at Bethany and Tufts Colleges, Harvard University, and the Universities of Göttingen, Breslau, and Berlin, and taught chemistry at Bethany College and Butler and Kentucky Universities. After leaving Mississippi in 1888 he was director of the West Virginia Agricultural Experiment Station.

MISSOURI

At the University of Missouri, at Columbia, the college of agriculture was established in 1870, and George C. Swallow (*312*) (1817–98) was the first professor of agriculture. He was a native of Maine, a graduate of Bowdoin College, and had been State geologist of Missouri and of Kansas. Little experimental work was done at the Missouri College until 1877, when Samuel Mills Tracy, a graduate of the Michigan Agricultural College, became assistant professor of agriculture and in 1879 professor of entomology and economic botany. With his aid, field experiments were carried on up to 1882. These were principally tests of varieties of corn, wheat, potatoes, apples, pears, peaches, grapes, and strawberries. Accounts of this work were published in the annual reports of the Missouri State Board of Agriculture.

In 1882 J. W. Sanborn, from the New Hampshire Agricultural College (p. 116), succeeded Professor Swallow. He organized the college farm and materially enlarged the experimental work there. In 1885 Levi Rawson Taft, a graduate of the Massachusetts Agricultural College in 1882 and thereafter assistant professor of horticulture there, became professor of horticulture at the Missouri College.

The regular publication of bulletins recording experimental work was begun in January, 1883, and 35 bulletins were issued prior to the establishment of the experiment station in 1888. These reported feeding experiments with pigs, calves, steers, and milk cows. They also reported experiments on subsoiling versus frequent and shallow tillage for corn and potatoes, the relation of dew to soil moisture, mulching and size of seed for potatoes, distance of planting and time of harvesting corn, use of fertilizers on corn and wheat, tests of

plows and of broad tires for farm vehicles, tests of varieties of wheat, corn, sorghums, soybeans, and alfalfa, and comparison of rotation with continuous growing of wheat.

Professor Taft reported tests of varieties of raspberries, blackberries, strawberries, grapes, and vegetables. Paul Paquin, as professor of veterinary science from 1885, published notes on pleuropneumonia, tick fever, and some other diseases of animals.

NEBRASKA

The University of Nebraska was opened for students in 1871, and its agricultural college was established the following year (*45*). Samuel R. Thompson (1833–96) was its first dean and professor of agriculture. He was born in Crawford County, Pa., graduated at Westminster College, New Wilmington, Pa., in 1863, and engaged in normal and high school work until going to Nebraska in 1872. From 1875 to 1882 he was again engaged in public school work in that State, including a term of service as State superintendent of public instruction from 1877 to 1881. Then he returned to the University of Nebraska as dean and professor of agriculture in the Industrial College, which at that time took the place of the agricultural college. In 1884 he became professor of physics in Westminster College.

Experimental work in agriculture began at the University of Nebraska in 1873 when sugar beets were grown on the college farm, together with varieties of wheat, oats, and barley. Samuel Aughey, professor of chemistry, at this time made analyses of some Nebraska soils (*75*) and began studies of the injurious insects in the State (*14*). In 1875 there were tests of varieties of potatoes, wheat, corn, beans, and peas, and 23 kinds of grasses and clovers. In 1880 a pamphlet of 31 pages was published, giving an account of the experiments at the college up to that time, including pig feeding to compare dry versus soaked corn, cost of raising an acre of sorghum and converting it into sirup, depth of sowing grain, and tests of varieties of wheat, potatoes, and sugar beets. No further report of experiments was made until after the organization of the experiment station under the Hatch Act.

In 1884 Charles Edwin Bessey (*224*) (May 21, 1845–Feb. 25, 1915) became dean and professor of botany and horticulture in the Industrial College. He was born at Milton, Ohio, graduated at the Michigan Agricultural College in 1869, and studied under Asa Gray at Harvard University. He immediately presented to the board of trustees a plan for experimental work. This included (1) popular experiments, such as breeding and feeding animals and field experiments with grain, grasses, and forage plants, and (2) scientific experiments, including meteorological observations, various studies of soils, irrigation, injurious insects, fungi, cross-fertilization of plants, and germination of seeds. Some observations on diseases of apples and plums and the smut of corn were published in press bulletins in 1885, and accounts of his work on the grasses of the State were given in reports of the State Board of Agriculture. Breeding and feeding experiments were begun by Henry H. Wing, who had come

from the New York Agricultural Experiment Station to be instructor in agriculture.

In 1886 Frank S. Billings, who had studied veterinary science in Germany, was employed as a full-time investigator of animal diseases. He undertook studies of swine plague and in 1888 published a bulletin of 400 pages on this subject.

NEW HAMPSHIRE

The New Hampshire Agricultural and Mechanical College was located at Hanover in connection with Dartmouth College from 1866 to 1891. Field and feeding experiments on a small scale were carried on there by Jeremiah Wilson Sanborn, who was farm superintendent from 1876 to 1882.

Sanborn was born at Gilmanton, N. H., February 4, 1847, educated at academies there and at Pittsfield, N. H., taught school at Gilmanton, and served in the New Hampshire Legislature. After leaving the New Hampshire College he was dean of the agricultural faculty of the University of Missouri until 1889 and then president of the Utah Agricultural College until 1894. The experiments at the New Hampshire College under his direction included the feeding of dairy cows, steers, and pigs; fertilizer experiments with corn, potatoes, and oats; the size of pieces of seed potatoes; time of cutting hay; and tests of sugar beets and sorghum.

George Herbert Whitcher, a native of Strafford, N. H., and a graduate of the New Hampshire College in 1881, became director of the experiment station in 1888. Up to 1888, experiments with fertilizers and in the feeding of dairy cows and steers had been carried on under his direction. A silo had been built and silage stored, analyzed, and fed to cows.

Accounts of the experimental work at the New Hampshire College prior to 1888 were published in the annual reports of the board of trustees.

PENNSYLVANIA

At Pennsylvania State College, W. H. Jordan was appointed professor of agriculture and agricultural chemistry in 1881 and served in these capacities until September 1885. The experimental work at the college was enlarged and more thoroughly systematized, and the farm work was accompanied by chemical research. The work during this period included general fertilizer experiments with dissolved boneblack, ground bone, nitrate of soda, dried blood, sulphate of ammonia, muriate of potash, lime, ground limestone, plaster, and yard manure; experiments to show the effects of different forms of phosphoric acid on crops in rotation; similar box experiments with fertilizers on barley; yield of wheat with different amounts of complete artificial fertilizer; effect of different fertilizers on the ash of tobacco; sorghum grown with various fertilizers; chemical studies of timothy and clover hays grown, harvested, and stored under different conditions; chemical studies of corn silage, and feeding experiments with silage for milk cows; feeding experiments with steers, in which early-cut versus late-cut timothy hay, or commercial hay, with or without cottonseed meal, was used in the

ration; analyses of wheat, "soft corn", and artificial feeding stuffs; seed tests; and study of methods of analysis. In 1884 Jordan was appointed chemist to the State Board of Agriculture and made the fertilizer control analyses. W. A. Buckhout made experiments on the variation of wild potatoes from Arizona under cultivation.

William Frear (*249*) (Mar. 24, 1860–Jan. 7, 1922), a native of Reading, Pa., and graduate of the University of Lewisburg (now Bucknell University) in 1881, who had been assistant chemist in the United States Department of Agriculture, succeeded Professor Jordan as professor of agricultural chemistry and was in charge of the experimental work from 1886 to 1887. H. J. Patterson, a graduate of the college and afterwards director of the Maryland Experiment Station, was an assistant in this work. Much of the work during these 2 years was a continuation, with some variations, of experiments previously begun; but there were also experiments in the cultivation and analysis of sugar beets and sorghum, fertilizer experiments with potatoes, tests and analyses of new varieties of grasses, cereals, and forage plants, root-washing experiments with corn, and study of the composition of desiccated apple pomace.

The experimental work prior to the organization of the experiment station in 1887 under the Hatch Act was recorded in the annual reports of the college and also largely in 16 bulletins. In the first bulletin, published by the experiment station in October 1887, Dr. Frear presented in some detail an historical outline of the experiments conducted by the college from 1857 to 1887 (*69*).

SOUTH CAROLINA

In 1882 about 20 acres of land belonging to the South Carolina College (afterwards University of South Carolina), then a land-grant college, were set apart for agricultural experiments. Numerous field tests of varieties of cotton, corn, small grains, grasses, and fertilizers were carried on under the direction of the professor of agriculture, R. H. Loughridge, afterwards of the California Station. The results of this work were given to the public in two reports, the first covering the operations of the years 1883, 1884, and 1885, and the second those of 1886 (*121*).

In December 1886, the State Legislature passed an act providing for the establishment of two experiment stations, to be known as the South Carolina Experiment Stations, one to be located in the Piedmont and the other in the lower tier of counties of the State. For their establishment $10,000 was appropriated. Their support was to be derived from a fertilizer tax. In July 1887, the Board of Agriculture proceeded to organize the station in the Piedmont at Spartanburg, where the people of the county had given 300 acres of land and $2,000 for the purpose. The farm in the lower tier of counties was located at Darlington, Darlington County, where the people of that county had given $5,000 in cash. In August of the same year 227 acres of land were purchased for the use of the farm. J. M. McBryde (p. 99), the president of the South Carolina University, was elected director of both stations.

HOUGHTON FARM

The only attempt in the United States to establish an agricultural experiment station through the munificence of one man deserves recognition. In 1876 Lawson Valentine, a philanthropic and public-spirited native of Massachusetts, conducting a prosperous business in New York City, purchased a tract of several hundred acres in the township of Cornwall, Orange County, N. Y., to which he gave the name of Houghton Farm. Soon afterwards he undertook to establish at this place a series of systematic agricultural experiments, which continued for about 5 years.

Henry Elijah Alvord (*215*, *216*) (Mar. 11, 1844–Oct. 1, 1904) was placed in charge as general manager in 1881. Manly Miles (p. 75) was made director of experiments, and served until 1882. An account of his experiments with Indian corn was published that year. D. P. Penhallow, formerly of the Massachusetts Agricultural College, was botanist and chemist until 1883, and wrote on meteorology and soil moisture, the normal condition of vegetable structure with reference to cell structures, peach yellows, and notes on fertilizer experiments in the orchard.

This experiment station, with its own organization, assignment of real estate, and equipment, was maintained at an expense to the proprietor approaching $20,000 per annum. The experimental work was grouped under four heads: (1) Agricultural physics, (2) plant growth, (3) diseases of plants, and (4) animal growth and production. The scheme included four corresponding series of publications, issued at irregular intervals. Papers were published and distributed during 1882, 1883, and 1884 in the three series first named.

The main work consisted of field experiments in growing corn continuously on the same land for several years. Extensive provisions were made for work in breeding and feeding dairy cattle and mutton sheep, and in dairy products, but no pamphlet publications on these subjects were issued.

The death of Mr. Valentine in 1888 put an end to this enterprise. Meantime Alvord had returned to the Massachusetts Agricultural College as professor of agriculture, later becoming president of the Maryland Agricultural College and director of the experiment station.

HISTORY OF THE HATCH EXPERIMENT STATION ACT OF 1887 (*173*)

On August 24 and 25, 1871, there was held in Chicago a convention of friends of agricultural education with special reference to experimental work at the agricultural colleges (*41*). Twenty-nine persons attended this meeting, including presidents or professors of land-grant colleges in Connecticut, Illinois, Iowa, Kansas, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, New York, and Pennylvania. Experimentation was much discussed, but there was considerable attention to the problems of agricultural instruction. Proposals were also made for the formation of an organization of agricultural colleges and technological schools. Finally Dr. Gregory, of Illinois, as president of the meeting, was authorized to

appoint a committee of one from each State to memorialize Congress and the State legislatures for the speedy establishment of experiment stations.

On February 15, 1872, a convention of delegates of State agricultural colleges, agricultural societies, and boards of agriculture met at Washington (*134*) in response to a call from Frederick Watts, United States Commissioner of Agriculture and for a long time president of the board of trustees of the Pennsylvania Agricultural College. At this meeting 32 States and 3 Territories were represented. From 9 States the same men who had represented the land-grant colleges at the Chicago meeting were present, while the colleges in Connecticut, Massachusetts, Michigan, New Jersey, New York, and Tennessee had new representatives. J. Sterling Morton attended from Nebraska, and Senator Morrill represented Vermont. A committee on experiment stations was appointed, including Hunter Nicholson, professor of agriculture and horticulture at East Tennessee University; Daniel Needham, of the New England Agricultural Society, from Massachusetts; John Hamilton, of Pennsylvania State College; S. W. Johnson, of the Yale Sheffield Scientific School, Cennecticut; and L. F. Allen, of the New York State Agricultural Society. This committee secured the cooperation of those members of the committee appointed at the Chicago meeting the previous year, and presented a report which was read by W. O. Atwater, then professor of chemistry at the East Tennessee University.

In this report the work of the European stations was briefly described and the need of similar institutions in the United States was pointed out, and it was stated that for the support of such stations—

the State legislatures should be appealed to for aid in their establishment and maintenance. The agricultural societies should make liberal contributions, and each landholder should be urged to add his subscription. The importance of the work makes it worthy of the aid of the Department of Agriculture, and of the direct support of Congress.

It was recommended that information regarding the organization, work, and results of the foreign experiment stations should be compiled and published. The committee was continued, and Johnson was requested to prepare a report on the character, value, and practicability of experiment stations.

Johnson engaged in active propaganda for the establishment of an experiment station in Connecticut (p. 82), and in 1873 prepared a report on Science as a Means of Agricultural Progress, for the Connecticut State Board of Agriculture. Ten thousand copies of this report were published, and it was widely circulated in Connecticut and elsewhere, and was also included in the tenth annual report of the Sheffield Scientific School (*109*).

In 1880 two organizations were formed, which helped to promote the cause of agricultural education and research in its national aspects. One of these was an informal association known as "Teachers of Agriculture." This held its meeting that year at the University of Illinois on the invitation of G. E. Morrow. Subsequent meetings were held at the land-grant colleges in Michigan in 1881, Iowa in 1882, Ohio in 1883, New York in 1884, and Indiana in 1885. Teachers of agriculture and horticulture from a number of States attended one or more of these meetings, and the discussions included matters relating to experimental work, as well as instruction.

At the first meeting a committee on conjoint experimentation was appointed. The chairman of this committee was N. S. Townshend, of Ohio. He presented the report of the committee at the meeting in Michigan, where he states "The principal business was to agree upon some plan for united and systematic agricultural experimentation." The committee urged that the States should "endow well-appointed experiment stations in connection with all these colleges." They recommended that the agricultural colleges should form a national association or regional associations.

> Each agricultural college or independent experiment station will report to its own association and all the associations should report to the Agricultural Department at Washington, and from that common center complete reports may be distributed over the whole country (*169*).

The Society for the Promotion of Agricultural Science (*156*), organized the same year under the leadership of W. J. Beal of the Michigan Agricultural College, considered chiefly the papers on experimental work presented at its annual meetings, but undoubtedly there was much informal talk about the needs of such work in different parts of the country.

The national interest in the experimental work of the United States Department of Agriculture and the State experiment stations was reflected in the proceedings of the Washington convention of agriculturists, held January 10–18, 1882 (*38*), in response to a call issued by the Commissioner of Agriculture, George Bailey Loring. He had for a long time been president of the New England Agricultural Society and a lecturer at the Massachusetts Agricultural College. He had also presided at the Washington Agricultural Convention of 1872 and had been a member of the 45th and 46th Congresses. Delegates from the State agricultural colleges, experiment stations, boards, and societies were invited to the convention of 1882, and 19 States were represented at the first roll call. Among those present, who were prominent in the affairs of the agricultural colleges and experiment stations, were W. O. Atwater and T. S. Gold, of Connecticut; S. H. Peabody and G. E. Morrow, of Illinois; G. H. Cook, of New Jersey; I. P. Roberts and G. C. Caldwell, of New York; and H. E. Alvord, then in charge of the experimental work at Houghton Farm in New York. Professor Cook read a paper on agricultural education in New Jersey, in which he dwelt especially on the work of the experiment stations. Professor Caldwell spoke on the experiment station as the educator of the farmer, and Professor Atwater described cooperative experiments with fertilizers carried on for five years in nine States. On motion of J. M. McBryde, of the University of Tennessee, a committee on cooperative experiments was appointed, which recommended that the United States Department of Agriculture prepare a digest of foreign experiments, endeavor to bring about cooperative experiments in this country on a carefully prepared plan, and ask Congress to appropriate money for this work.

As an outcome of this convention Seaman A. Knapp, of the Iowa Agricultural College, drafted "a bill to establish national experiment stations in connection with the agricultural colleges in the various states." This bill (H. R. 6110) was introduced in the House of Representatives by C. C. Carpenter, of Iowa, May 8, 1882. It was referred to the Committee on Agriculture but was not reported back.

A second series of three conventions on agricultural education, animal industry, and cotton were held at Washington under the presidency of Commissioner Loring, January 23–29, 1883 (*39*), at which 29 States and Utah Territory were represented. Among those present at the educational meeting were W. H. Brewer, of Connecticut; S. A. Knapp and James Wilson (then in Congress), of Iowa; T. C. Abbot, of Michigan; W. W. Folwell, of Minnesota; James Law, of New York; H. P. Armsby, then of Wisconsin; C. A. Goessmann, of Massachusetts; E. L. Sturtevant, of New York; N. S. Townshend and C. E. Thorne, of Ohio; and G. W. Atherton, of Pennsylvania. Senator Morrill was a delegate representing the Vermont State Agricultural Society. H. W. Wiley, then representing Purdue University in Indiana, read a paper on the relations of science to the industries and arts (*39, p. 32*), which led to considerable discussion regarding experimental work in agriculture. In the course of this discussion, Thomas H. Dudley, representing the New Jersey State Agricultural Society, made the following statements:

> I shall be very glad to see the time when every State in this Union shall have established an agricultural experiment station in connection with a farm for carrying on practical field experiments.
>
> It is a practical subject which the Government should take up; and not only the General Government, but I would be glad to see a large appropriation sufficient to establish an experiment farm and an agricultural experiment station upon it in every State, so that both might be carried on for the people of the whole State (*39, p. 50*).

As the final outcome of the interest in agricultural experimentation aroused in this meeting, a resolution, introduced by Seaman A. Knapp, at the request of President Abbot, of the Michigan Agricultural College, was adopted, indorsing the Carpenter bill.

Professor Knapp then moved that a committee of five be appointed to prepare a statement on this subject for presentation to the Committee on Agriculture of the House of Representatives. This was approved by the convention, and Messrs. Knapp and Abbot, together with Stephen D. Lee, of the Mississippi Agricultural College; Paul Chadbourne, of the Massachusetts Agricultural College; and E. E. White, of Purdue University, were appointed on this committee.

The Carpenter bill was considered by the committee and with some slight modification was given by Professor Knapp to A. J. Holmes, of Iowa, since Carpenter was no longer a Member of Congress. Congressman Holmes introduced this bill (H. R. 447) in the House of Representatives on December 10, 1883, when it was referred to the Committee on Agriculture. Its text was as follows:

> Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That in order to enable the Department of Agriculture to fulfill the design and perform the duties for which it was established, as declared in the organic act creating the said department, to-wit, "to acquire and diffuse among the people of the United States useful information on subjects connected with agriculture in the most general sense of that word, and to procure, propagate, and distribute among the people new and valuable seeds and plants," institutions shall be established in connection with each of the agricultural colleges in the States providing such colleges, with an improved farm in connection therewith, and placed under the conduct of such colleges, to be called and known as "national experiment stations."
>
> Sec. 2. That it shall be the object and design of the said national experiment stations to conduct original researches or verify experiments on the physiology

of plants and animals, the diseases to which they are severally subject, with the remedies for the same; the chemical composition of useful plants at their different stages of growth; the comparative advantages of rotative cropping as pursued under a varying series of crops; the capacity of new plants or trees for acclimation within the isothermal limits represented by the climate of the several stations and their vicinity; the analysis of soils and waters; the chemical composition of manures, natural or artificial, with experiments designed to test their comparative values for raising crops of different kinds; the composition and digestibility of the different kinds of food for cattle; the scientific and economic questions in the production of butter and cheese; and all other researches or experiments bearing directly on the agricultural industry of the United States.

Sec. 3. That the said experiment stations shall be placed under the general control of the regents or trustees of said agricultural colleges, who shall have power to employ a professor for each agricultural college who shall act as superintendent of the experiment stations established under this act.

Sec. 4. That the said professors shall make such reports to the Commissioner of Agriculture from time to time as he may direct. The general character of the work and of the experiments to be performed at each station shall be determined by the Commissioner of Agriculture, the president of the college where the station is located, and the professor in charge of said station.

Sec. 5. That to each agricultural college providing for experiment stations under this act, to pay the salaries of the professors and superintendents of the said experiment stations, the wages of the laborers employed in their operations, and the cost of the experiments and researches connected with their conduct as heretofore specified, the sum of fifteen thousand dollars is hereby appropriated, out of any money in the Treasury not otherwise appropriated, or so much thereof as may be necessary to cover expenditures actually made for said purposes; the money to be drawn quarterly from the Treasury of the United States, upon a certified statement of the amounts actually expended at each station, properly indorsed by the college board of audit, the professor in charge, and the Commissioner of Agriculture.

Sec. 6. That upon the passage of this act, before the agricultural college in any State can draw any funds as provided, the legislature of such State shall pass an act accepting such trust and agreeing to conduct an experiment station in accordance therewith.

As chairman of the committee and president of the Iowa Agricultural College, Knapp issued a circular (*113*), in which he briefly stated the history of the bill, gave the names of the committee appointed by Commissioner Loring, and presented reasons for establishing agricultural experiment stations in the several States because of the diversity of their climates and agricultural production and the broad range of problems to be solved, as well as the desirability of aiding the Department of Agriculture in its researches and in obtaining useful seeds and plants for distribution in different parts of the country. He thought the stations should be connected with the agricultural colleges because (1) it would be economical to take advantage of their organization, faculties, buildings, and equipment; and (2) the investigations would greatly benefit the students "as object lessons and would perfect and give practical value to the work of the colleges, as contemplated in the original law creating them." The supervision to be exercised by the Commissioner of Agriculture "will systematize their work throughout the United States and will avoid too much repetition of experiments at different stations."

From this time the efforts of the friends of agricultural education in the land-grant colleges, the agricultural societies, the grange (*11*), and other organizations were concentrated on securing the passage of an experiment station act by Congress.

The Holmes bill was not generally acceptable to the colleges, largely because it seemed to make the stations virtually branches of the De-

partment of Agriculture and to put them to a considerable extent under the control of the Commissioner of Agriculture. It was therefore remodeled, and when it had been considered and modified by the Committee on Agriculture of the House of Representatives it was favorably reported from that committee by Congressman Cullen, of Illinois, on July 2, 1884.

The report (2034) (*192*) accompanying the Cullen bill emphasized the importance of having State stations as supplementary to experimental work of the Department of Agriculture.

The amount proposed to be appropriated by this bill would not of itself be sufficient to establish and maintain such stations, but the colleges being already established, or most of them, the farms, professors, laboratories, and apparatus can be utilized without additional cost, requiring only the payment of salaries of the few scientific investigators, and for labor and material necessary for the special purposes of experimentation.

It was still a bill (H. R. 7498) to aid the Department of Agriculture in acquiring and diffusing agricultural knowledge, but the stations were to be distinctly departments of the land-grant colleges and under the control of their governing bodies and were to make their reports to the governors of the States. It was expressly provided that nothing in the act "shall be construed to authorize said Commissioner to control or direct the work or management of any such station except as to the standard of valuation of commercial fertilizers." He might furnish forms for the tabulation of results of experiments, indicate lines of inquiry, and "in general furnish such aid and assistance as will best promote the purpose of this act." Sections were added which required the stations to publish and distribute bulletins every three months, gave them the franking privilege for their publications, and required the trustees of the colleges to agree to spend the Federal money according to the provisions of the act, to maintain a farm of at least 25 acres, and to give a bond "for the faithful expenditure and accounting for all moneys so received." One-fifth of the first year's appropriation might be spent for the erection, enlargement, or repair of station buildings but only 5 percent thereafter. If any money was not expended during the fiscal year of its reception, that amount was to be deducted from the next annual appropriation. Nothing in the act was to impair or modify the legal relation between the college and the State. A group of college presidents were in Washington in the winter of 1884–85 to forward the passage of this bill, but Congress was not ready to take action.

The Congressional Record shows that between February 1883 and March 1885 petitions for Federal aid for agricultural experiment stations in the several States were received by Congress from California, Illinois, Maine, Michigan, New Jersey, North Carolina, Ohio, South Carolina, Texas, and Wisconsin.

In November 1885 the National Grange, which for several years had favored the establishment of agricultural experiment stations, adopted the recommendation of its committee on agriculture with reference to the Cullen bill—

that this Grange cordially approve the object and purpose of the bill and would gladly hail its passage, so modified in its working details, as to suit and subserve the varied situations and interests in the various States (*135*).

87445—37——9

When Grover Cleveland became President on March 4, 1885, he appointed Norman J. Colman, of Missouri, Commissioner of Agriculture (p. 61). In the Senate James Z. George, of Mississippi, was the leading Democratic member of the Committee on Agriculture and Forestry, and William H. Hatch (*255*) (fig. 8), of Missouri, was chairman of the House Committee on Agriculture.

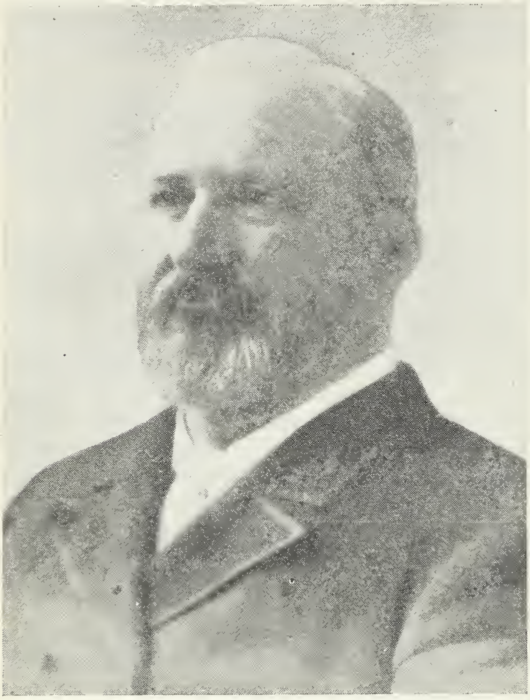

FIGURE 8.—William Henry Hatch, 1833–1896. Author of the first act providing Federal aid for State agricultural experiment stations.

As publisher and editor of Colman's Rural World, and long a member of the State Board of Agriculture and of the board of curators of the University of Missouri, Commissioner Colman was greatly interested in agricultural education and research. On May 6, 1885, he issued a call for a convention of representatives of the different agricultural colleges and allied State institutions. Among the subjects to be considered at this convention he mentioned—

> the question of experiment stations, and the relation they should hold to this Department, the best means of bringing about Congressional action, and of harmonizing the interests of the different state institutions and the National Department.

The convention was held in Washington at the Department of Agriculture July 8 and 9, 1885 (*40*). It was attended by representatives of at least 28 States and 3 Territories, including land-grant colleges and agricultural experiment stations in Alabama, California, Connecticut, Dakota, Georgia, Illinois, Iowa, Kansas, Kentucky, Maine, Maryland, Massachusetts, Michigan, Mississippi, Missouri, Nebraska, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Tennessee, Texas, West Virginia, and Wisconsin.

The committee on order of business and resolutions included Commissioner Colman; H. E. Alvord, of New York; S. D. Lee, of Mississippi; S. A. Knapp, of Iowa; M. C. Fernald, of Maine; G. W. Atherton, of Pennsylvania; Edwin Willits, of Michigan; and C. W. Dabney, of North Carolina. This committee presented the following resolution for discussion:

> *Resolved,* That the condition and progress of American agriculture require national aid for the investigation and experimentation in the several States [and Territories], and that, therefore, this convention approves the principles and general provisions of what is known as the Cullen Bill of the last Congress, and urges upon the next Congress the passage of this or a similar act (*40, p. 27*).

This resolution was unanimously adopted. In the course of the discussion Professor Cook, of New Jersey, explained the action of representatives of the agricultural colleges, who had attended a hearing on this bill before the House Committee on Agriculture at the previous session of Congress. Besides himself, he mentioned Presidents Atherton, of Pennsylvania, and Field, of Ohio, and W. H. Brewer, of Connecticut, as being present at this hearing. He said that at first the committee was indifferent to this bill and did not think it was of any consequence, but after holding it for over 2 months they voted unanimously to report it favorably to the House. There were enough Members of Congress willing to vote for the bill to pass it, but pressure of other business prevented action on it at that session. The chairman of the committee, however, gave assurances that he would introduce it again at the next session.

To aid in securing the passage of the experiment station bill, a resolution was adopted, providing for the appointment of a committee of three—

to cooperate with the Commissioner of Agriculture in endeavoring to secure such legislation by Congress as may be reported by this convention and that this committee be authorized to add to its membership at its discretion in connection with any particular measure before Congress.

Messrs. Atherton, Willits, and Lee were the members of this committee.

Near the end of the convention an advisory committee consisting of one representative from each State and Territory and the Department of Agriculture was appointed. President Atherton was elected its chairman and was authorized to choose five other members, who with him would constitute an executive committee to determine the time and program of the next convention and a plan for permanent organization. He selected Messrs. Cook, Knapp, Peabody, Curtis (Texas), and Newman (Alabama).

There was much discussion regarding cooperation of the Department and the experiment stations. Resolutions on this subject proposed by the committee on business, which were adopted with some amendments, are interesting in view of the final form of the Hatch Act and the work of the Office of Experiment Stations.

These resolutions were as follows:

Whereas one principal object of this convention is the establishment of closer relations between the Department of Agriculture and all institutions systematically engaged in active labors for agricultural progress; therefore,

Resolved, That in the opinion of this convention the first practical measure to secure cooperation in fulfillment of the admirable suggestions of the Commissioner of Agriculture is the creation of a bureau or division in the Department of Agriculture, supplied with the necessary clerical force, which shall be the special medium of intercommunication and exchange between the institutions intended to be represented by this convention and the central office in charge of the details of this general plan of cooperation.

Resolved, That this convention respectfully recommends to the Commissioner, as one of the most important functions of the proposed bureau, the compilation and publication of a periodical bulletin of agricultural progress, not less than quarterly, and an annual report based thereon. This bulletin should contain, in a popular form, ready for the use of the people and the press, the latest experiences and results in the progress of agricultural education, investigation, and experimentation, in this and in all other countries.

Resolved, That as a necessary part of the intended cooperation the schools and experiment stations here represented regard themselves as bound to make definite plans for supplying said bureau with such regular reports of their

operations as may be called for by the Commissioner; and that the Commissioner be requested to provide, as far as needed, uniform blanks for such reports, and these institutions further regard themselves as obligated to promptly respond, as far as practicable, to calls from said bureau for information on special topics which the Commissioner may need at the central office (*40, p. 90*).

On December 10, 1885, Senator George, of Mississippi, at the request of President Lee, of the Mississippi Agricultural and Mechanical College, introduced a bill (S. 372) identical with the Cullen bill, which had been approved by the college committee. This bill was referred to the Senate Committee on Agriculture and Forestry.

In the House of Representatives Mr. Holmes reintroduced his bill December 21, 1885. Other bills to establish agricultural experiment stations in connection with the land-grant colleges were introduced in the House between December 21, 1885, and January 7, 1886, by Messrs. Allen of Mississippi, Heard of Missouri, Buchanan of New Jersey, Outhwaite of Ohio, Curtin of Pennsylvania, Pettibone of Tennessee, and La Follette of Wisconsin. All these bills were referred to the Committee on Agriculture and nothing further was done with them.

On January 7, 1886, Mr. Hatch introduced the bill (H. R. 2933) approved by the college committee. This bill was considered by the Committee on Agriculture and reported back to the House, with amendments and a report, on March 3, 1886. It was then referred to the Committee of the Whole House. The amendments chiefly included the Territories as beneficiaries of the measure.

Mr. Hatch's report on the bill pointed out that reliable experiments with seeds and plants, which would give results suited to the agricultural conditions in different parts of the United States, must be carried on in the several localities, and that agents with scientific acquirements were needed to collect accurate information on agricultural matters, and thus strengthen the work of the Department of Agriculture.

Foreign competition in wheat, meat, and other products was increasing and should be met with applications of science which would "increase production at a decreased cost and at the same time preserve the fertility of our soils." The success of experimental work in agriculture at Rothamsted, England, and at 148 stations on the continent of Europe, was cited to show the usefulness of such stations and the wide range of their activities.

Attention was called to the fact that—

More than 2,000 books and pamphlets were published by experiment stations between the years 1852 and 1877. * * * Combining as they do the precision of scientific methods with an intelligent regard for the requirements of practical operations, it is not surprising that they have come to be looked upon as the most important aids to successful farming as well as the foremost agency for the advancement of agricultural science. The work being done by European Stations is equally needed in the United States and is already begun in obedience to an imperative public demand.

Brief statements were then made about the experimental work of the stations already established in eight States and of the Pennsylvania State College. Mention was made of similar work in nine other States. This bill "only proposes to give a practical direction to agencies which Congress has already created" under the Land-Grant Act of 1862 and "to increase the efficiency of these colleges in their relations to agriculture exclusively."

Petitions favoring the passage of such legislation were received in Congress from 34 States, including those from legislatures, State boards of agriculture, Farmers' National Congress, National and State Granges, and other agricultural organizations.

In his annual report, dated November 15, 1886, Commissioner Colman gave a brief account of the history of the experiment stations (*33*) and their needs, and made an argument for the bill for Federal aid then pending. He had appointed a special agent to visit the stations and report on their facilities, work, and needs. He desired the following amendments to the Hatch bill: (1) That only one station in each State should receive the Federal fund, (2) that the State should determine to what institution this fund should go, (3) that the allowance for buildings and repairs should be $5,000 the first year and at least $1,000 annually thereafter, and (4) that authority and money should be given to the Commissioner of Agriculture to establish a special central office in the Department of Agriculture, not to dictate to or control the stations, but to act as a clearing house and medium of communication between them; to criticize, digest, and consolidate their results; and to issue a periodical containing accounts of their work. He would dignify this office by giving it a chief equal in ability to the station directors.

Senator George's bill was reported back favorably on April 21, 1886, but did not receive any extended consideration until January 17–27, 1887. There was little opposition to the purposes of the bill, but numerous amendments were offered. Much objection was made to the supervision of the stations by the United States Commissioner of Agriculture, and changes were made in the bill to put the stations fully under the control of their State governing boards.

Section 1 was amended by striking out the words "the Department of Agriculture" in the first line, and by making the stations clearly "under direction of the college or colleges, or agricultural departments of colleges."

Section 3, which dealt with this matter in another way, was then omitted.

Section 4, in which authority was given to the Commissioner of Agriculture to determine a "standard of valuation of the ingredients of commercial fertilizers", was discussed at length. A substitute for this section, which had been drafted by President G. W. Atherton, of Pennsylvania, was presented. This left out all reference to fertilizers but provided that—

> It shall be the duty of the United States Commissioner of Agriculture, by the advice and with the consent of a commission composed of the directors, or a majority thereof, of the stations receiving the appropriations hereinafter made, to lay out certain lines of work and methods which each of said stations shall prosecute and adopt to the extent of at least 15 per cent of said appropriations; but nothing herein contained shall be construed to authorize said Commissioner of Agriculture to control or direct the work or management of any such station, except in the manner annually provided and approved by the said commission, and to the extent of the income above set forth. * * * And, for the purpose of securing further co-operation among such colleges or stations and of co-ordinating the results of their work, it shall be the duty of the Commissioner of Agriculture to collate and publish, at least monthly, the results of such work in the United States and in foreign countries, and to provide a suitable place for holding annual meetings or conventions of the directors or other representatives from such colleges or stations.

This was not satisfactory to those who wanted to minimize the functions of the Department of Agriculture in relation to the experiment stations. Finally section 4 became section 3 in the simplified form now in the Hatch Act.

Section 5, regarding station publications, was slightly modified and became section 4 of the act.

Section 6 became section 5 and was modified by striking out definite reference to "the salaries and wages of the director and other employees of said stations" and the provision that—

no such payment shall be made to any station until the trustees or other governing body of the college at which such station is located shall have executed, under their corporate seal, and filed with the Secretary of the Treasury, an agreement to expend all moneys received under this act for the sole and exclusive purpose and in the manner herein directed, and to maintain a farm of at least 25 acres in connection with such college, and shall also have executed and filed with said secretary their bond, in the penal sum of fifteen thousand dollars, with two sufficient sureties, approved by the clerk of the Court of Record in each State, conditioned on the favorable expenditure of and accounting for all moneys so received.

Another amendment provided that the station fund should be paid from the proceeds of sales of public lands. There was, however, some objection to this limitation on the ground that the time would come when there would be no proceeds of public land available for this purpose.

Another amendment was that the station fund was "to be specially provided for by Congress in the appropriations from year to year."

Section 7 became section 6, and section 8 became section 7.

Section 8 of the amended bill was a new provision. That part of it which related to the stations not connected with colleges was the result of definite agitation.

C. E. Thorne, of Ohio, was a member of the convention of agricultural college representatives of 1885. As editor of Farm and Fireside, he said in the issue of December 15, 1886: "In our opinion it should be left to the option of the legislatures of the various States whether the fund should be bestowed upon the agricultural colleges, or upon institutions created especially for this line of work."

In the History of Ohio State University (*129*), by Alexis Cope, it is stated that the amendment regarding separate stations was brought about under the leadership of J. H. Brigham, president of the Ohio State Board of Agriculture, and master of the State Grange, and with the aid of Senator John Sherman of Ohio.

The National Grange, on November 18, 1886 (*136*), expressed its approval of such an amendment by adopting a report of its committee on education, of which Mr. Brigham was a member. This report also recommended that another amendment should provide that in any State having no experiment station under State control and in which agricultural education was neglected by the land-grant college, the Hatch fund should be put under the direction of the State Board of Agriculture and given to an independent experiment station whenever such a station was established.

A memorial embodying these recommendations was sent to Senator Sherman, who was at this time president pro tempore of the Senate, and he presented it in the Senate January 14, 1887 (*170*).

The amendment regarding the separate stations was introduced by Senator Dawes, of Massachusetts, who was supported by Senators Platt and Hawley, of Connecticut.

It is interesting to know that the second part of section 8, which authorizes State legislatures to give the whole or part of their Hatch fund to agricultural colleges, separate from universities or other institutions not distinctly agricultural, was introduced by Senator Spooner, of Wisconsin, who thought that the agricultural department of the University of Wisconsin had not been a success, and that it was almost impossible to secure the attendance of any larger number of agricultural students in classical institutions where from 300 to 500 students were pursuing classical or scientific courses.

Sections 9 and 10 were also new provisions adopted by the Senate.

The Territories were by various amendments given full benefits of this act.

About all of the original Holmes bill that was left unchanged was section 2, regarding the work of the stations and the amount of the Federal appropriation.

The George bill, thus radically amended, was passed by the Senate without a record vote, on January 27, 1887.

It came before the House on January 29 and was referred to the Committee on Agriculture. That committee accepted it as a substitute for the Hatch bill, and it was reported back to the House by Mr. Hatch on February 2, 1887, with the statement that his committee recommended its passage for the reason given in their report on his bill. It came up for final action in the House February 25, 1887, when it was passed without debate by a vote of 152 ayes to 12 noes. It was signed by President Cleveland on March 2, 1887.

President Willits, in his report to the governing board of the Michigan Agricultural College (*207*) made interesting comments on events attending the passage of the Hatch Act. As a member of the college committee he had spent 7 weeks in Washington in December 1885 and January 1886, and 10 days the following winter.

> By dint of hard work it [the experiment station bill] passed the Senate in a mutilated form and went to the House, where, near the close of the session, under suspension of the rules and therefore without chance for amendment, it passed by an overwhelming vote. * * * The bill as originally drafted by the committee, and which was called the Hatch bill for the reason that Mr. Hatch was the very efficient chairman of the Committee on Agriculture in the House, carried the annual appropriation in the bill itself. But in the three days' discussion in the Senate the whole bill was sadly mutilated, not from intent, but from a desire to harmonize conflicting demands. Among other things it was thought best that this law should be no exception to the general rule, which is that all expenditures should be specifically appropriated annually by Congress. * * * By accident the word "hereafter" was not incorporated in the amendment. It was supposed that the specific appropriation made in the preceding words would carry the appropriation for the first year, and the intent was that only hereafter should the amount be in the regular appropriation bill. Mr. Hatch did not discover the error in the haste of the closing session (I was not present, the college being in session) and the omission was not noticed until after Congress adjourned. The Comptroller of the Treasury holds that the money is not appropriated. But the law is the law of the land, and under it we have the claim for $15,000 a year as completely as any United States official for his salary.

The first appropriation for the experiment stations was made in a special act of February 1, 1888, "to carry into effect the provisions"

of the Hatch Act, and, in spite of the provision in section 5 of that act that the money must come from the proceeds of the sale of public lands, the appropriation was made "out of any money in the Treasury" not otherwise appropriated. Beginning with July 18, 1888, the Hatch fund has been carried in the annual appropriation act for the Department of Agriculture.

The Agricultural Appropriation Act of July 18, 1888, carried an appropriation of $10,000 to enable the Commissioner of Agriculture to carry out the provisions of section 3 of the Hatch Act, and "to compare, edit, and publish such of the results of the experiments made under section 2 of said act by said experiment stations as he may deem necessary; and for these purposes the Commissioner of Agriculture is authorized to employ such assistants, clerks, and other persons as he may deem necessary." Under this authority, Commissioner Colman established the Office of Experiment Stations October 1, 1888.

Up to the passage of the Hatch Act the Federal Government had appropriated money for agricultural research only to the Patent Office and its offshoot, the United States Department of Agriculture. The Carpenter and Holmes bills recognized this general policy and proposed only to establish experiment stations in connection with the agricultural colleges "in order to enable the Department of Agriculture to fulfill the design and perform the duties for which it was established."

The Hatch Act in its final form established a new policy of relationship between the Federal Government and the States by granting money to the States for agricultural experiment stations, which were thus to be distinctly State institutions. As stated by E. W. Allen (*3*) in an address at the semicentennial of the Connecticut Experiment Station:

> This Nation-wide subsidizing of research in agriculture was evidence of change which had come in the conception of the relationship of the Federal Government and the States. It was a recognition of a joint responsibility in developing the industry of agriculture on a high stage of efficiency, and it was a new expression of what the general Government may do under the Constitution for the promotion of public welfare.

AGRICULTURAL EXPERIMENT STATIONS IN THE STATES AND TERRITORIES UNDER THE HATCH ACT, 1888–1905

During the year following the passage of the Hatch Act the legislatures in all the States gave their assent to its provisions, and during 1888 agricultural experiment stations in all the 38 States and the Territory of Dakota received their share of the appropriation made by Congress under that act.

When the act passed, experiment stations connected with land-grant colleges were in operation in 8 States—Alabama (2), California, Kentucky, Maine, New York, Tennessee, Vermont, and Wisconsin. Independent stations were in existence in 7 States—Connecticut, Louisiana (2), Massachusetts, North Carolina, New Jersey, New York (Geneva), and Ohio. More or less systematic experimental work was being done in 13 other States—Colorado, Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Mississippi, Missouri,

Nebraska, New Hampshire, Pennsylvania, and South Carolina. In Louisiana in 1888 the two stations previously existing, and a new station created in north Louisiana, were attached to the land-grant college. During that year additional stations under the Hatch Act were established at the land-grant colleges in Massachusetts and New Jersey, at the Storrs Agricultural School in Connecticut, and in 24 other States and the Territory of Dakota. Thus at the end of that year there were 46 stations in the United States, 43 of which received the Hatch fund. Massachusetts, New Jersey, and New York each had one station wholly supported by State funds. In 1890 stations under the Hatch Act were established in the Territories of Arizona, New Mexico, and Utah, and two small State stations were begun in north and southeast Alabama.

In 1891 Hatch stations were established in Oklahoma, Washington, and Wyoming. Idaho in 1892 and Montana in 1893 each added a station, but the two State stations in Alabama were given up. There were then 55 stations, 49 of which received the Hatch fund. In 1892 the New Hampshire Station was separated from Dartmouth College at Hanover and became a department of the newly established College of Agriculture and Mechanic Arts at Durham. The Ohio Station was moved from Columbus to Wooster. In 1896 the two stations in Massachusetts were combined. A Federal station was established in Alaska in 1898, and the annexation of Hawaii brought in the Sugar Planters Station there, so that at the end of the nineteenth century there were 56 stations in the United States, of which 52 received the Hatch fund.

In 1900 a station was established at Tuskegee Institute in Alabama, and the following year a State station in Missouri and Federal stations in Hawaii and Puerto Rico were added, making 60 in all. This number remained stationary during the next 5 years. In 1906, 55 of these stations received the Hatch fund, 3 were Federal stations, and 2 were wholly supported by the State.

In an attempt to satisfy local demands the States undertook the establishment of substations. In 1889 there were 14, and their number rapidly increased until in 1894 there were 40. The ruling of the Office of Experiment Stations against the use of the Hatch fund for the maintenance of substations reduced their number to 11 in 1897. The use of State funds brought them up to 16 in 1899 and to 28 in 1904. For the most part they were small enterprises for testing varieties and making simple field experiments and were conducted by superintendents, who sometimes were agricultural college graduates, with the aid of farm laborers. Many of them were temporary, depending on the changing attitude of legislatures or State boards of control. From about 1904, however, there was a growing tendency to make them more permanent and to give them more substantial State aid. This was particularly true in the large States having regional agricultural problems.

RELATION OF THE FEDERAL GOVERNMENT TO THE STATIONS

The stations receiving the Hatch fund are State institutions subsidized by the Federal Government. They also receive the franking privilege for their publications under regulations made by the Post-

master General. As departments of the land-grant colleges their reports are annually sent to the Bureau of Education (now Office of Education), representing the Secretary of the Interior, as well as to the Secretary of Agriculture.

The Hatch funds are paid quarterly in advance from the United States Treasury to the treasurer or other properly certified officer of the institution receiving the benefit of the Hatch Act. The appropriations under the Hatch Act are annual rather than permanent and are included in the appropriation acts for the Department of Agriculture.

The Hatch Act provides—

that in order to secure, as far as practicable, uniformity of methods and results in the work of said stations, it shall be the duty of the United States Commissioner (now Secretary) of Agriculture to furnish forms, as far as practicable, for the tabulation of results of investigations or experiments; to indicate from time to time such lines of inquiry as to him shall seem most important, and in general to furnish such advice and assistance as will best promote the purposes of this act.

OFFICE OF EXPERIMENT STATIONS

In accordance with this provision the Office of Experiment Stations was established October 1, 1888, to represent the Secretary of Agriculture in his relations with the stations, and W. O. Atwater was named its first director For the first six years this Office had no regulatory functions. It collected and diffused information regarding agricultural experiment stations at home and abroad. For this purpose it established Experiment Station Record in 1889, and in the same year began the publication of farmers' bulletins and other reports and bulletins, including a Handbook of Experiment Station Work (in 1893). In 1889 the Association of American Agricultural Colleges and Experiment Stations asked the Department of Agriculture to publish the proceedings of its annual meetings. This was done through the Office of Experiment Stations until 1910. Issuance of a card index of publications of the stations began in 1891.

After the Hatch Act was passed, undue stress was laid, by some authorities controlling the policy of the land-grant colleges, on the words in the first clause in the act which made it an object of the stations to aid in "diffusing among the people of the United States useful and practical information on subjects connected with agriculture." This was interpreted as permitting the teaching of agriculture and the carrying on of various kinds of extension work. The colleges and stations in some States were somewhat loosely managed, especially when the institutions were weak or in a formative stage. Therefore, complaints that the Hatch funds were being diverted from their proper use reached the Department of Agriculture. These led Secretary Morton to ask Congress for authority to look into this matter, and his request resulted in a clause, carried in the appropriation item for the stations since 1894, directing the Secretary of Agriculture to "prescribe the form of annual financial statement" required by the Hatch Act and to "ascertain whether the expenditures under the appropriation hereby made are in accordance with the provisions of the said act and make report thereon to Congress."

Under this authority financial schedules were prepared and sent to the stations, and an annual visitation of each station was decided

upon and has since been made by representatives of the Office of Experiment Stations. The first visitation showed enough irregularities in the use of the Hatch fund to fully justify the action of Congress and the need of explicit understanding between the Department and the stations on a number of points relating to their finances. These were covered as far as practicable by a series of rulings by the Director of the Office of Experiment Stations. During their visits to the stations the representatives of the Office not only examined the accounts and vouchers pertaining to the Hatch fund; but they also conferred with the college presidents, and station directors and officers, and sometimes with members of the boards of control, regarding the actual use of the fund, the plans, progress, and needs of the station work. At these and other times advice was also often given regarding organization, subjects and plans of work, personnel, equipment, and publications.

It was a settled policy of the Office from its beginning to take a helpful and sympathetic attitude toward the authorities and workers in the stations and to bring to them whatever it could as the result of its wide survey of such institutions at home and abroad. Close contact with the land-grant institutions brought a realization that in many of them both the teaching and the research in agriculture were weak and poorly organized, and that both must be strengthenend simultaneously if the results most useful to the farming people of the country were to be attained. The Office therefore adopted a liberal policy in dealing with problems which arose under the Hatch Act and attempted to act progressively on questions affecting the expenditure of the Hatch fund. It also encouraged liberal appropriations by the States to supplement the Federal funds, as well as cooperative enterprises between the stations and the different bureaus of the Department of Agriculture.

As time went on, many stations obtained considerable funds from different sources, some of which could be expended for purposes not appropriate to the Hatch Act, and this in general made the administration of the Hatch fund easier and more satisfactory.

When the Office of Experiment Stations was established, the States as a rule felt strongly that it ought not to undertake research work. This was partly from a fear that, being close to Congress, it might secure funds which would make its work in certain lines overshadow that of the individual stations. This fear, however, was dissipated as the policy of the Office developed, and little, if any, objection was made to the appropriations for nutrition investigations (p. 185) begun in 1894, which were largely spent in cooperation with stations in different parts of the country, nor to the irrigation investigations (p. 195) begun in 1898, out of which developed the drainage investigations (p. 195) in 1902.

In 1898 the Alaska Experiment Station and in 1901 the Hawaii and Puerto Rico Stations were put under this Office. All these research enterprises grew in variety and extent so that by 1906 they formed a large share of the work of the Office.

The Office was represented at the meetings of the Association of American Agricultural Colleges and Experiment Stations from 1889, under a clause in its constitution providing for membership of the Department of Agriculture. In 1891 an amendment specifically pro-

vided for a delegate representing this Office, in addition to a general representative of the Department, who was often the Assistant Secretary of Agriculture. Other members of the Office participated in the meetings of the association, and the Office was often represented on important committees. After 1895 the Director of the Office was bibliographer of the association.

Since the agricultural courses in the land-grant colleges had much to do with the training of station workers and agricultural teachers and were also means for disseminating the results of the stations' work to large numbers of students, the Office, without express authority of law, undertook to promote the teaching of agriculture in these colleges and somewhat later in secondary and elementary schools. From 1895 the Director of the Office was a member of the standing committee on teaching of agriculture of the Association of American Agricultural Colleges and Experiment Stations and from 1901 its chairman. In 1902 the Director was dean of the first graduate school of agriculture, which was held at Ohio State University. A special officer was appointed to conduct other agricultural education work of the Office.

In a similar way the Office from the beginning promoted the farmers' institutes and in 1903 an experienced institute worker was added to its force.

RELATIONS OF THE STATIONS WITH ASSOCIATIONS

The experiment stations, as well as the colleges with which they are connected, were brought together to form a national system of agricultural education and research through the Association of American Agricultural Colleges and Experiment Stations organized in 1887. The stations had equal representation with the colleges in the annual meetings of the association and on its executive committee which promoted the general interests of the association at and between its meetings. Questions relating to the stations were often discussed at general sessions of the association and in the earlier years in sections representing agriculture and chemistry, horticulture and botany, and entomology, but in 1903 a section on experiment station work was substituted for these sections, and in 1905 a standing committee on station organization and policy was added.

The association did much to establish and strengthen the stations and to aid in their administration on a permanent and substantial basis.

The officers of the stations also participated to a considerable extent in the Society for the Promotion of Agricultural Science organized in 1880, the Association of Official Agricultural Chemists organized in 1884, the American Association of Economic Entomologists organized in 1889, the Association of Experiment Station Veterinarians organized in 1897, the Society of American Bacteriologists organized in 1899, the American Society for Horticultural Science organized in 1903, and the American Breeders Association organized in 1903.

ORGANIZATION OF THE STATIONS

The stations connected with the land-grant colleges under the Hatch Act are by law departments of these institutions. The act,

however, makes an exception in the case of the State stations established separately from the colleges prior to its passage and in this way State stations in Connecticut, New York, and Ohio receive, in whole or in part, the benefits of the Hatch Act.

As the station work in a considerable number of States grew out of attempts made by the professors in the agricultural colleges to add experimental inquiries to their duties as instructors before there were definite funds for research work in agriculture, the tendency, after the funds were supplied for experiment station purposes, was to use these to supplement the work of various departments of the college rather than to conduct the experiment station actually as a distinct branch of the college. This arrangement was also quite generally favored in the States where the colleges were new institutions with limited funds which could be used for college purposes. Experience has shown, however, that to do its most efficient work the station must have a compact organization as a distinct branch of the college, and must have its operations clearly differentiated from those of the departments of instruction.

As departments of colleges the stations, as a rule, are under the general management of the governing boards of the institutions. The separate State stations have their own governing boards. The more immediate supervision of station affairs is often intrusted to a standing committee of the board.

As a rule the duties of the board are confined to determining in a general way the policy and lines of work of the station, appointing the members of the staff and fixing their terms of office and compensation, deciding on the character and extent of expenditures, and approving and auditing the accounts. In the earlier days some governing boards determined and supervised the work and expenditures of the stations in considerable detail. This, however, often led to unfortunate results, especially in those States where, owing to political and other causes, the personnel of the boards changed rapidly and where as a consequence there were frequent changes in the personnel and work of the stations, making it difficult for them to conduct thorough or satisfactory research.

In a large number of States, from the first, the presidents of the colleges sustained the same relation to the stations that they had to other departments of the colleges, but in a considerable number of States they were at first also directors of the stations. This was not a good arrangement; and as the land-grant institutions grew, it became impracticable for their presidents to give the stations proper attention. Gradually, therefore, they withdrew from the positions of station directors. In 1905 this arrangement remained in only four States.

As a separate officer, the station director often combined general executive duties with the carrying on of investigations in some special lines or with teaching in the college. In the land-grant universities the head of the college of agriculture often held the dual position of dean and director. This arrangement, which in a number of States has persisted until the present time, has had some unfortunate results and has, in a measure, weakened both the teaching and the research in agriculture. Even from the beginning the stations needed the full-time services of an expert officer as director, who in the early days might properly have taken part in the research work.

If there had been a will to do so, the administrative difficulties which have been commonly urged as a reason for combining the offices of dean and director might have been overcome and a stronger organization of the whole agricultural work of the institution effected.

In some States during the period now under consideration, the station director had large powers and responsibilities in the management of the station. In other States the planning of the work and even details of administration were largely committed to a council composed of department heads or of these officers and some members of the governing board.

The other members of the station staff represented one or more branches of agriculture or of science related to agriculture. In a large number of instances these officers combined teaching with experiment station work. The passage of the Hatch Act led to a general effort of the land-grant colleges to make their instruction related to agriculture more comprehensive and attractive. This brought about a relatively wide organization of the stations, partly because the colleges desired to have experts in a number of different lines who could combine teaching with research.

In 1896, out of a total of 584 persons on the station staffs, 266 were teaching, and in 1905, out of 845 station workers, 423 were teaching. The early station work was therefore often too diffuse, and there were too many relatively small and superficial projects. The science of agriculture had hardly been formulated or taught, and there were very few men representing the different branches of agriculture who were qualified to carry on good experimental work in these lines. For this reason the so-called agriculturists or horticulturists, appointed as station officers for a number of years after the passage of the Hatch Act, often were able to conduct only simple field or feeding experiments, and these were in many cases very imperfectly planned and recorded.

The more scientific work of the stations was done by persons trained in the fundamental natural sciences, particularly chemistry and botany, and these men often conducted both laboratory and field and feeding experiments. There were also a number of well-trained entomologists and veterinarians, and during this period the sciences of vegetable pathology and bacteriology were considerably developed, and special workers in these lines became available to a certain extent.

After the stations in this country and abroad had accumulated a considerable fund of tested knowledge relating to different branches of agriculture, a real science of agriculture began to be developed in the last years of the nineteenth century, and specialists in different divisions of this science began to be trained in our agricultural colleges. Then we find agronomists and experts in animal husbandry, poultry raising, and dairying, replacing the agriculturists in the stations.

In addition to the scientific force there were usually persons of practical experience employed as foremen of farms, dairymen, or feeders of cattle, and clerical assistants, including accountants, stenographers, and typists. Women were often employed in these clerical positions. Laborers were employed regularly by the year or month, or worked as occasion might demand by the day or hour. A considerable number of college students were employed as assistants and

laborers at the stations. Special experts, scientific assistants, and other workers were from time to time employed to conduct particular investigations.

The tenure of office for members of the station staff was quite variable, ranging from a period of 1 year to an indeterminate tenure, practically depending on efficiency and good behavior. The salaries of station officers also had a wide range, depending upon the amount and character of service required as related to duties performed for the college or otherwise.

The substations were in immediate charge of a superintendent, who was assisted by a small force of laborers. As the activities of the substations were chiefly confined to field operations, all work requiring the use of laboratories and expert knowledge in various scientific lines was done either at the central station or under the immediate supervision of the station officers in charge of such work. The superintendent of the substation was directly responsible, either to the director of the station or to the governing board, and carried on operations planned by the director, the station staff, or the governing board.

The statistics of the station staffs (table 1), taken from reports of the Office of Experiment Stations, show the number of workers in the several lines at different times and also to some extent reveal the progress in specialization prior to 1906.

TABLE 1.—*Personnel of the agricultural experiment stations*

Title [1]	1889	1895	1900	1905
Directors and assistant directors	63	67	71	74
Substation superintendents	14	40	10	27
Agriculturists	13	55	74	58
Agronomists				44
Horticulturists	40	61	75	82
Viticulturists	5			
Foresters				4
Animal husbandmen			14	56
Poultrymen				12
Dairymen		11	30	39
Veterinarians	19	24	29	36
Farm foremen		25	24	30
Chemists	106	124	143	166
Botanists	30	36	55	56
Plant pathologists				11
Mycologists	2	7	17	4
Bacteriologists				18
Entomologists	29	43	50	65
Zoologists			6	4
Biologists	5	11	6	3
Physicists	3	3	7	5
Geologists	3	5	6	7
Meteorologists	10	15	16	8
Irrigation engineers	1	7	7	13
Librarians (1890)	5	8	10	12
Secretary-treasurers	13	26	27	30
Clerks	16	27	51	46
Miscellaneous	17	28	30	54
Total	402	557	693	815

[1] In some cases 1 person served in more than 1 capacity.

INCOME OF THE STATIONS

The annual income of the stations was mainly derived from Federal and State appropriations, fees for fertilizer analyses under State

laws, and sales of products from the station farms. In some cases contributions were received from individuals or communities. For example, sugar planters in Louisiana contributed to the support of the station at New Orleans, the Connecticut Station had a bequest of about $80,000 as a permanent endowment under the will of W. R. Lockwood, and when the Ohio Station was moved to Wooster in 1892 it received $85,000 from Wayne County.

During the period from 1888 to 1905, inclusive, the income of the stations more than doubled. The progressive development of their income is shown in table 2.

TABLE 2.—*Income of the agricultural experiment stations*

Source	1888	1894	1900	1905
Hatch fund	$585,000	$719,830	$719,999	$718,163
State fund	89,000	167,775	247,281	540,467
Fees for fertilizer analyses	17,400	28,360	70,927	82,428
Sales	4,000	47,299	90,088	93,058
Individuals and communities	15,000	13,825	2,420	8,925
Miscellaneous	----------	19,067	40,142	72,693
Total	710,400	996,156	1,170,857	1,515,734

EQUIPMENT OF THE STATIONS

The land-grant colleges generally had farms connected with their agricultural departments prior to the establishment of the experiment stations, and these farms had in many cases been used more or less for experiments with varieties of agricultural and horticultural plants, fertilizers, and feeding stuffs for different kinds of livestock. When the stations were established the colleges immediately provided them with land. In many cases the station was given a definite portion of the college farm for its exclusive use. In some cases it was permitted to use such portions of the farm as it needed for experiments from time to time, and in other cases the entire farm was turned over to the station. All of the stations established by the States independently of the colleges had farms connected with them, except the Connecticut State Station. There were also farms at the substations. The station farms were generally divided into limited areas on which plat experiments were conducted; horticultural plantations, including vegetables and small, bush, and orchard fruits; fields devoted to experiments in growing crops on a relatively large scale; fields on which forage crops were grown for use in experiments with silos, the feeding of animals, dairying, etc.; and pastures or woodlands. These farms were often provided with more or less elaborate systems of drainage, and in many of the States west of the Mississippi River there were irrigation ditches, with the accompanying water rights.

As the work of the stations increased in extent and complexity there was a general tendency to use larger areas of land. In some cases more land was used than the resources of the station warranted, and the field work then became superficial and more or less unsatisfactory through lack of proper supervision or inability to make careful use of the material grown. Station officers were sometimes hindered in their experimental work by duties, imposed on them by the colleges, relating to the management of land not actually used for experimental purposes.

As the Hatch Act permitted only very small expenditures for buildings and repairs, most of the buildings which the stations used were supplied by the colleges or by the States through special appropriations for their construction. Many of these buildings were used jointly by the colleges and stations. Beginning about 1900, large buildings of brick or stone were constructed at a number of the land-grant colleges to house their agricultural work. These contained the executive and business offices of the stations, libraries, museums, and scientific laboratories. In other cases substantial separate buildings were erected for the departments of agriculture, horticulture, chemistry, and botany. Vegetation houses, in a number of cases including arrangements for pot experiments, were quite common. Insectaries, in which insects might be bred and their life history studied, were built at a number of stations, the first house of this description having been erected in 1889 at the station connected with Cornell University in New York. In a similar way provision was made at a number of stations for the culture and treatment of fungus and other diseases of plants.

Generally each station had one or more barns which were used for handling livestock, grain, and forage crops, or were fitted up with special arrangements for feeding experiments with different kinds of livestock. At a number of stations buildings were set apart for experimental work in dairying. In some cases these were fitted up to be run as working creameries or cheese factories. Silos were quite generally a part of the equipment of the stations, being either separate structures or parts of other buildings. At first these were experimental structures as regarded size, form, construction materials, etc. Piggeries and poultry houses, built with special reference to experiments with these animals, were found at a number of the stations.

Special buildings for experiments in particular lines, such as sugar making, tobacco curing, or animal diseases, were built at some of the stations. In 1900 the Pennsylvania Station erected a building containing a respiration calorimeter for experiments with large animals. In 1902 a small experimental flour mill was erected at the Minnesota Station for testing the milling qualities of different varieties of wheat as related to their nutritive value, and the following year a similar mill was built at the South Dakota Station, which was then working especially on durum wheats.

The stations were, as a rule, well equipped with scientific apparatus suited to the lines of work in which they were engaged. This was especially true in the departments of chemistry, botany, bacteriology, and entomology. During this period the apparatus for studies in vegetable physiology and pathology and agricultural physics was rapidly augmented. Besides the apparatus which was more directly the property of the stations, a large amount of apparatus belonging to different divisions of the colleges was available for the use of the stations.

The stations made or purchased very large collections of specimens needed for use in their work, especially in the departments of entomology, botany, vegetable pathology, agronomy, and horticulture. They also had at their command the general collections of the land-grant colleges, which in some cases were among the most extensive in this country.

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Many stations maintained separate libraries, which usually consisted of limited working collections of reference books; scientific manuals; files of American and foreign scientific and agricultural journals; the publications of American and foreign experiment stations and departments of agriculture; reports of scientific, agricultural, horticultural, livestock, and dairy associations; and miscellaneous Government and other documents on scientific and agricultural subjects. In other cases the books obtained especially for station workers were merged with the general college library, the full privileges of which, however, the station officers enjoyed. College and local libraries were quite generally at the disposal of the station workers. These ranged all the way from collections of a few thousand books to libraries with hundreds of thousands of volumes. To a limited extent station workers were also able to avail themselves of the large agricultural library at the Department of Agriculture at Washington through loan for special purposes under certain restrictions. The libraries were generally provided with card catalogs and indexes.

The numbers and kinds of livestock kept by the stations varied according to the lines of work in which they were engaged. At some of the stations a limited number of animals of different kinds were kept permanently. This was especially true of herds of dairy cattle. At other stations most of the animals were purchased from time to time for use in experiments and sold when the experiments were completed. In a number of cases the college furnished the station with such animals as it needed for its general business and experimental purposes. The animals kept at the stations included different breeds of dairy and beef cattle, sheep, swine, horses, mules, chickens, ducks, geese, and other poultry.

The stations were, as a rule, well provided with farm machinery and implements of improved patterns. In some cases these were obtained by the stations for practical tests of their utility for different purposes. In their experiments, especially in dairying and field operations, the stations made much use of a large number of special forms of implements and machines. The stations did not, however, attempt the testing of agricultural machines in any broad way, nor did they as a rule use peculiar forms of machinery which it would not be practicable for the farmer or dairyman to utilize in general practice.

VALUE OF ADDITIONS TO EXPERIMENT STATION EQUIPMENT

Considerable sums were spent each year in increasing the station equipment. This is illustrated in the following statement (table 3) of the value of additions to equipment in a few typical years.

TABLE 3.—*Additions to station equipment in stated years*

Item	1890	1894	1900	1905
Buildings	$161,681	$43,822	$89,416	$68,834
Library	14,875	9,286	10,784	10,119
Apparatus	36,325	22,711	19,397	19,166
Livestock	13,949	13,373	22,009	23,862
Farm implements	28,779	15,824	17,015	14,621
Miscellaneous	16,746	31,382	8,850	19,016
Total	272,355	136,398	167,471	155,618

LINES OF WORK OF THE STATIONS

Experimental work in agriculture in this country began, as we have seen, with practical and scientific investigations in a few lines, carried on chiefly by college professors supplementary to the work of instruction. The early work of the first independent station related chiefly to studies of the chemical composition of fertilizers. This led to the establishment of a fertilizer control in a number of the States which founded such stations at a relatively early period. Thus the farmers and legislatures were led to look upon the stations as proper agencies for the performance of certain inspection duties on matters relating to agriculture.

The stations soon began to issue reports and bulletins describing their operations. In order that the farmers might better understand what the stations were doing, it was found necessary to describe to them the results of similar investigations elsewhere, and in general to make them acquainted with the progress of agricultural science and practice in various lines. In this way the stations came to be looked upon as bureaus of information, and they were therefore more and more called upon to give advice to the farmers on all sorts of agricultural topics, either through correspondence or through publications. Particularly as the stations were organized in the newer States and Territories, where there were no well-organized boards of agriculture or commissioners of agriculture, they constituted the only State agencies from which the farmers could get information regarding their art.

After the passage of the Hatch Act there was a large and sudden expansion of the amount of scientific and practical investigation along agricultural lines, but it was soon found that the time was not ripe for the exclusive devotion of this fund to original research. Moreover, a considerable portion of it was necessarily spent for general administrative purposes, correspondence, and printing and distribution of publications.

It was necessary, first, to train a sufficient number of investigators, to collect information regarding the natural agricultural conditions and resources of many of the States and Territories, and to diffuse among the farmers a large amount of compiled information, before they would be in a position to understand and utilize the more scientific work of the stations. As the work of the stations further developed, their success in obtaining results which were useful to the farmers aroused a very much greater demand for information and for inspection work, and State legislatures therefore from time to time increased the revenues of the stations, with the distinct understanding that the funds thus given would be devoted to such work, together with practical tests and demonstration experiments, or to diffusion of information. This made it all the more difficult for the stations whose income was wholly or largely confined to the Hatch fund to keep their work strictly within the provisions of the act of Congress.

In studying the work of any one station it is necessary to ascertain how far and in what directions the funds granted by the National Government have been supplemented by State funds and for what purposes these different funds may be used. The general result of their historical development has been to broaden the work of the stations so as to include a great variety of functions.

Along many of the lines in which the agricultural experiment stations have been working, the different branches of the United States Department of Agriculture have also been pursuing investigations, and there has been a large and increasing amount of cooperation. Much of this work is of such a character that, in general statements regarding the lines and results of work of the stations, it is impracticable wholly to segregate their operations from those of the Federal Department.

In a general way the work of the stations in the United States may be grouped under the following heads: (1) Investigations involving original features, (2) verification and demonstration experiments, (3) studies of natural agricultural conditions and resources, (4) inspection and control work, and (5) dissemination of information. It will be readily understood, however, that most of the enterprises of the stations are of a mixed character. Originality will, as a rule, be found only in some particular features of an investigation or in the adaptation of well-known facts or principles to special conditions.

INVESTIGATIONS INVOLVING ORIGINAL FEATURES

The investigations of the stations may be classified in a general way on the basis of the different divisions found in their organization. Thus it may be said that the investigations of the stations comprise studies in physics, chemistry, botany, zoology and especially entomology, geology, meteorology, agronomy (field-crop production), horticulture, forestry, physiology (of man and domestic animals), zootechny (animal industry), veterinary science, agrotechny (agricultural technology) including especially dairying, and rural engineering. During the period now under consideration there were very few studies which would now be classified under agricultural economics. Here and there the cost of producing crops or animals was superficially estimated, together with the profit if sales were made. But as a rule the minds and efforts of the station workers were on the problems affecting agricultural production or the utilization of these products for human or animal food.

In most of these lines the investigations included studies in improving methods, devising new apparatus and appliances, relating scientific principles to the science and practice of agriculture, working out new practical applications on the basis of well-known facts and principles, or solving special problems.

Under the head of physics, considerable attention was given to studies on soils, especially as regarded the methods for the physical examination of soils, the movement of soil water, and the apparatus required for such investigations. The Wisconsin Station studied the rate of percolation from saturated sandy loam and clay loam soils and the loss of water by evaporation from such soils, mulched and not mulched, and the movement of nitrates in the soil.

In chemistry, studies with a view to improving methods of analysis continued to occupy the attention of a considerable number of stations. This work was done quite largely in connection with the Association of Official Agricultural Chemists. It related chiefly to methods of analyzing soils, fertilizers, plants, foods, and feeding stuffs. The station workers also cooperated with this association in establishing food standards as a basis for the determination of

adulteration. A number of pieces of special chemical apparatus were devised. These included apparatus adapted to particular kinds of investigations, or intended to increase the speed or multiply the operations of laboratory processes for scientific or practical purposes, and devices for making the chemical examinations required in agricultural industries.

A very large number of analyses of economic plants, foods, feeding stuffs, dairy products, fertilizers, and other agricultural materials, especially those distinctively American, were made for the first time in the chemical laboratories of the stations. Systematic chemical studies of a considerable number of staple crops, such as wheat, corn, cotton, tobacco, alfalfa, rice, sorghum, kafir, sugarcane, and potatoes were made at different stations. These sometimes included examinations of these plants at different stages of growth.

A considerable number of special chemical investigations were conducted. Among these were studies of the proteids of wheat and other cereals and of eggs, by the Connecticut State Station; alkali and alkali soils, by the California Station; humus, by the Pennsylvania Station; effect of irrigation waters on the composition of plants, by the Utah Station; the changes in sugarcane juice and its products, by the Louisiana Station at New Orleans; the poisoning of cattle in relation to sorghum, kafir, and cornstalks, by the Nebraska Station; silage, by the Wisconsin Station; the leaves, root, and trunks of old apple trees and nursery stock, by the New York State Station; losses of nitrogen in barnyard manure, by the New Jersey Station; availability of fertilizing ingredients in soils and manures as affected by lime, magnesia, etc., by the Rhode Island Station; and the constituents of the nitrogen-free extract of feeding stuffs, by the Vermont Station.

In the earlier years the station chemists often had entire charge of investigations which later were considered to be in the fields of soils, agronomy, or animal husbandry. As specialization of the branches of agricultural science proceeded rapidly from the beginning of the twentieth century, specialists in these branches were commonly associated with the chemists in investigations pertaining to their respective fields. Chemistry was usually an adjunct to the investigations on the fertilizer requirements of plants and soils, on human and animal nutrition, and on dairying. Reference to work in which chemists were associated with the station specialists will be made further on.

In botany a considerable amount of systematic work was done, especially in the newer States. New species of useful and injurious plants were discovered and described. Herbaria showing with more or less completeness the economic flora of individual States were collected. New light was thrown on the botanical relations of species of economic plants. Among the more elaborate systematic studies and publications were those of the Tennessee and Iowa Stations on grasses. The stations in Nevada and Arizona studied the grasses and forage plants of the ranges, with special reference to the discovery of new species which might be utilized in animal feeding or to the better management of the ranges. The poisonous plants of the ranges were investigated by the Nevada and Wyoming Stations.

Weed distribution, propagation, seedlings, and seeds were studied by numerous station botanists. The distribution of the roots of different plants in the soil was studied at several stations. The botanical work of the stations was, however, principally along the lines of vegetable physiology and pathology and bacteriology. At first the station botanist covered all these fields or, in the case of bacteriology, the chemist or veterinarian had charge of work in that line. But, gradually, vegetable pathologists and bacteriologists were added to the station staffs.

The studies in vegetable physiology included investigations of special problems and devising methods and apparatus for such studies. Several stations made investigations of the cause and prevention of sun scald of fruit trees, the influence of various enzymes upon the germination of old seeds of different kinds, and the effect of alkali on the germination of seeds and the growth of plants. The Vermont Station made an elaborate study of the flow of maple sap. The effect of arc and incandescent electric lights on plant growth was studied by the New York (Cornell) Station and during 8 years by the Massachusetts Station. In a similar way illuminating gas or acetylene was used in experiments by these stations and by the New Hampshire and West Virginia Stations.

The bacteriological work of the stations included isolation, culture, and description of many species of useful and pathogenic bacteria in air, water, soil, fertilizers, plants, food, feeding stuffs, and other agricultural products, and of those bacteria affecting useful and injurious animals. Methods and apparatus for bacteriological investigations were devised, and means for the repression of pathogenic bacteria were worked out. Among the more important investigations in this field were those on soil bacteria at the Michigan, New Jersey, Delaware, and West Virginia Stations, on dairy bacteria at the New York State and Connecticut Storrs Stations, on silage bacteria at the Wisconsin and New Hampshire Stations, and on the bacteria of legumes and root nodules at the Michigan and Oklahoma Stations.

The stations took a considerable part in the development of both the scientific and practical phases of vegetable pathology, in which there was great activity during this period. They worked out the life histories of many fungi and bacteria injurious to cultivated plants, and devised methods and apparatus for repressing diseases of plants. Among the plant diseases which received most attention at the stations were those affecting potatoes (scab, rot, and blight), cotton, tobacco, cereals (smuts and rusts), flax, clover, sweetpotatoes, beans, celery, asparagus, tomatoes, grapes, pears (blight), peaches, and apples (rots, scabs, and cankers).

In zoology a number of the stations, particularly in the West, made systematic and other studies of injurious mammals (especially gophers and rabbits), and of useful and injurious birds. There were also special investigations of the life history and culture of oysters, made by the New Jersey and Washington Stations, and of the life history of nematodes. But by far the most extensive and important work of the stations in zoology was in the field of economic entomology.

The work in entomology included collecting large numbers of specimens of insects to determine their economic importance in dif-

ferent regions; describing many new species and working out their life history in whole or in part; adding to the knowledge of many beneficial and injurious insects, including in many cases the completion of their life histories; studies in breeding insects, especially as a means for their investigation; the discovery or invention of methods and appliances for repressing injurious insects; and devising methods and appliances for the study of insects. As regards well-known insects injurious to field crops or horticultural plants, the station investigations often dealt with local or regional peculiarities in the life history of the insects or in the efficacy of methods for their repression. Up to 1905 the stations had published nearly 4,000 bulletins or reports dealing exclusively with entomology. Many of these were largely or wholly compilations, but a goodly number contained accounts of original observations or experiments. Among the insects on which the station entomologist made extensive studies resulting in the development of effective repression methods were the codling moth, plum curculio, San Jose scale and other scale insects, chinch bug, Rocky Mountain locust, woolly aphis, the apple, tobacco, and hop aphids, cottonworm, fringed-wing apple-bud moth, tent caterpillars, red spiders in California, greenhouse white fly, peach borer, grape rootworm, Mediterranean flour moth, forest insects, and insects affecting stored grains.

The stations experimented with a great variety of insecticides, dealing especially with new modifications or combinations of well-known materials and mixtures, such as Paris green, arsenate of lead, crude petroleum, kerosene, whale-oil soap, lime-sulphur with salt or copper sulphate, and hydrocyanic acid gas, etc. Times of spraying and number of sprays were often investigated. The New Jersey Station made extensive experiments in control of mosquitoes.

The Association of Economic Entomologists, organized in 1890 by entomologists of the United States Department of Agriculture and the stations, through its annual meetings, was an important aid to the work of the stations in this field.

AGRONOMY

In agronomy (field-crop production) a very large amount of work was done. It included tests of varieties, selection and breeding, fertilizer and tillage experiments, drainage and irrigation investigations, and studies of methods of harvesting and storage. At first much of the work was done by persons who had had little or no scientific training and often, therefore, the experiments were not very different from the field-crop work of the more intelligent farmers. But with the improvement of the college courses in agriculture and the growing specialization of the agricultural work of the land-grant colleges, particularly in the second half of this period, trained agronomists took the place of agriculturists. The field-crop work of the stations was then done more carefully and systematically. The study of methods of investigation in the field of agronomy was begun, as well as constructive criticism of the results previously obtained.

All the stations engaged in tests of varieties of field crops. These tests included comparisons of varieties already grown in the regions about the stations, or of kinds of plants new to those regions. Tests

of varieties were sometimes made because this was an easy way of doing considerable field work which gave promise of speedy practical results, but more often because there was a real demand from farmers for reliable information regarding varieties which might be better than those in common use. It is perhaps difficult to realize how large was that portion of the United States over which agriculture was yet a comparatively new industry when the stations began work under the Hatch Act. In the vast region west of the Mississippi River there had been little systematic effort to determine varieties of plants best adapted to different localities, or the possibilities of introducing new crops to supplement those already grown. Broadly considered, the work of the stations in testing varieties during this period served a very useful purpose. But as the work progressed it became evident that, outside of the testing of plants new to their respective regions, the stations' distinctive work on varieties of field crops would be in the improvement of varieties by systematic experiments in selection and breeding.

Varieties of corn were tested at nearly all the stations. A summary in 1904 of 1,297 tests of 490 varieties of corn in 7 States gave an average yield of 2.5 bushels more per acre from white varieties than from yellow varieties. In general, individual varieties showed large fluctuations in yield in different years, even in the same field. The length of time required for maturing the crop of a single variety often varied as much as a month in different years.

In the newer wheat-growing areas much progress was made in determining whether it was best to make this a winter or spring crop. In several States having large areas of limited rainfall the durum wheats were tested, with the result that a new industry of considerable proportions was established. Nonsaccharine sorghums of different kinds were widely tested, and kafir became an important crop in Kansas, Oklahoma, and some other Southwestern States. Many varieties of oats and barley were tested, and important new varieties of these crops were introduced by the Minnesota and Wisconsin Stations.

Alfalfa of native or imported varieties was shown to be a useful and successful crop in many localities in the East and West. Soybeans and vetches of various kinds were widely tested. In the Southern States cowpeas, velvetbeans, and peanuts were grown experimentally with important results.

Many species and varieties of grasses from American and foreign sources were tested at many stations. The Mississippi Station tested 586 species of grasses and forage plants on soils differing widely in character and fertility. The rape plant was successfully introduced in a number of States as an adjunct to the sheep industry.

Testing of sugar beets on a large scale resulted in the determination of the sections where they might yield satisfactory sugar content. The station experiments in Michigan and Utah had much to do with the establishment of a beet-sugar industry there. The Louisiana Station at New Orleans tested many varieties of sugarcane from different countries. Varieties of tobacco were tested by the Connecticut State, Pennsylvania, and Kentucky Stations.

As the result of experiments by the California and other western stations, the Australian saltbush was introduced on arid and semiarid

alkali lands where it rendered available for grazing thousands of acres of land practically worthless before.

The improvement of varieties of field crops at the stations by breeding and selection soon took the form of systematic studies and the development of special methods. This work was greatly expanded, and by 1905 it was carried on by over one-half of the stations and in some places on a large scale. The Minnesota Station was a leader in the study of methods for this work and had specially devised apparatus for grading, planting, and for threshing, and special forms of records. This station also carefully distributed to substations and selected farmers the products which seemed useful. The Illinois Station, which in 1889 had begun crossing corn for larger plants and increased yield, soon undertook the selection of varieties for special constituents in the kernels, particularly protein and fats, and was followed in this endeavor by stations in Kansas, North Dakota, and Nebraska. Varieties of wheat of better milling qualities and larger yields were obtained by selection and cross breeding.

The Oregon Station bred vetches for higher protein content, the Idaho Station studied the protein content of wheat at different altitudes, and the Kentucky Station attempted to develop a form of burley tobacco with more erect leaves and more elastic staple.

The New York (Cornell) Station undertook an extensive breeding experiment with varieties of timothy from this country, Europe, and Australia. In Vermont and Michigan, potatoes were bred for disease resistance. In South Carolina, cotton was bred for improved staple and for disease resistance, and in Texas for increased yield and earliness of maturity.

An effort was made by the Delaware Station to further increase the sugar content of sorghum in the hope of solving the problem of successful sugar making from this crop. Improved varieties of sugarcane were produced by the Louisiana Station at New Orleans. In Minnesota and North Dakota breeding experiments were made with varieties of flax for seed or fiber.

Experiments with fertilizers, under the Hatch Act, were to a considerable extent in continuation of those undertaken by the stations previously established. For the most part such experiments were confined to the older States east of the Mississippi River. They included tests of a large number of different forms of commercial fertilizers and of farm manures for different crops, the kinds of plants best adapted to green manuring and the methods of their management, the forms of fertilizers (e. g., potassium salts) best adapted to the production of high quality in the product; the fractional application of fertilizers to hasten growth and prolong ripening; making fertilizing material (e. g., leather refuse and fish) available to plants; and the economic utilization of refuse materials (e. g., seaweed) for fertilizers. Methods and times of applying fertilizers also received considerable attention.

The Massachusetts Station continued investigations on the effects of special fertilizers on fruits, vegetables, and field crops, including experiments with different combinations of plant food on the quality and quantity of tobacco grown in the Connecticut River Valley. Pot experiments were made to determine the effect of continued use of fertilizers upon soils and the relative value of different phosphates

and potash salts. Cylinder experiments related to the extent of variations in effects of fertilizers due to the individuality of plants. The effect of liming on the growth of clovers and timothy was studied in a similar way.

In 1894 the Rhode Island Station began a long-continued series of plat and pot experiments on the acidity of upland soils, its treatment with lime, and the effect of lime on different fertilizers applied to such soils and on different kinds of vegetables. Experiments with sodium as a substitute for potassium were also made here and at the New York State Station.

The Connecticut State Station made extensive studies on the chemical composition of corn as affected by fertilizers. The availability of various forms of nitrogen was studied in a large number of pot cultures and with different soils and fertilizers and under various conditions.

The New Jersey Station made cylinder experiments on the relative availability of barnyard manure and nitrogenous fertilizers. The Ohio Station made a long-continued investigation of the maintenance of fertility. This investigation included field experiments with fertilizers and manures on 850 permanent plats, chiefly of one-tenth acre each, located in five districts of the State and upon soils widely different in character. The Illinois Station made pot experiments with type soils from different parts of the State and conducted studies on the management of soils in 15 or 16 different localities.

The West Virginia Station made a 5-year comparison of stable manure and commercial fertilizers on meadows used for hay. Field experiments by the Kentucky Station showed that the depleted bluegrass soils of the State needed potassium. Fertilizer experiments with tobacco and hemp were conducted. The permanency of the effect of potassium fertilizers on corn was studied, as well as the effect of fertilizers on shrinkage and on the ratio of cob to kernel.

The North Carolina Station studied phosphates with reference to the fineness of grinding and their relative availability as fertilizers; the use of tobacco byproducts as fertilizers; the effect of different fertilizers on various soils of the State; and the nitrification in different soils resulting from the use of different fertilizers. The South Carolina Station experimented with fertilizers for cotton to determine the amounts and proportions of nitrogen, phosphorus, and potassium required, and to compare different methods of applying fertilizers to this crop and the effect of the several nutrient elements on the growth of the plant. Similar experiments were made with corn, wheat, oats, and rice.

The Alabama Station determined the fertilizer needs of the most important soil belts of the State and gave special attention to green manuring, particularly with legumes. The Mississippi Station made experiments with various fertilizers for cotton grown on a variety of soils. The Louisiana Sugar Station worked 11 years on the manurial requirements of sugarcane.

Irrigation problems in arid and semiarid regions and in humid climates were investigated with special reference to frequency, time, and method of irrigation and the amount of water required for various crops.

In Utah, Colorado, Montana, and Wyoming the station work in general related to farming under irrigation. In 1905 the Utah Sta-

tion had two small farms at which were studied such problems as the maximum and minimum quantities of water required for different crops at different stages of growth, the relation of soils and subsoils to quantity of water needed, the movement of water in soils, and the flooding versus furrow method of applying water to crops. The Wisconsin Station from 1889 to 1901 studied the water requirements of corn and the influence of irrigation on yield. Similar work was done by the Louisiana and New Mexico Stations. In Utah the proportion of ears to stover increased with increased application of water.

A great variety of tillage experiments with corn, wheat, cotton, sugarcane, sugar beets, rice, and other field crops was made by the stations in different parts of the country. In Utah, North Dakota, Wyoming, and other States where rainfall is limited, tillage experiments connected with a system of dry farming were made, the principal object being to conserve the soil moisture. In this region problems relating to summer fallowing were also studied. Among the stations dealing in a broad way with the problem of maintaining soil fertility were those of Mississippi and Ohio. In 1905 the latter station was using in this work more than 1,300 permanently located plats in different parts of the State.

Experiments with terracing and other means for preventing soil erosion were made by southern stations, particularly in Mississippi and South Carolina. Among the stations making systematic experiments with rotation of crops were those in Illinois, Indiana, Louisiana, Minnesota, North Dakota, Pennsylvania, South Dakota, and Washington.

A number of stations were comparing mature and immature or light and heavy seeds, seeds from different latitudes, and, in the case of corn, seeds from the butt, middle, and tip of the ear. There were also experiments in thick and thin seeding, planting at different depths, deep and shallow cultivation, frequent cultivation, subsoiling, fall and spring plowing, planting winter catch crops, spacing and intercultural experiments. The practice of detasseling corn was studied and generally condemned. Observations on the rate of growth of corn were made by the Pennsylvania and Illinois Stations. At the latter station, experiments for several years led to the conclusion that rate of growth is to a considerable degree independent of temperature but dependent on the stage of development of the corn plant. Experiments in growing tobacco under shade were made by the Connecticut State, Kentucky, and Pennsylvania Stations.

Experiments in harvesting wheat, oats, and barley at different stages of growth and at different periods of ripening; curing hay at different stages of development; the economy of different methods of harvesting corn; the shredding of cornstalks; and the curing and fermenting of tobacco were carried on. The Louisiana Station studied the harvesting of sugarcane at different times before and after freezing. The losses in curing and keeping corn fodder in the field were determined by the Indiana Station. The stage of maturity at which corn is most profitably harvested was studied by the stations in Georgia, Illinois, Iowa, Kansas, New York (Geneva), Pennsylvania, Vermont, and Wisconsin.

An important part of the work of the stations relating to the preservation of farm crops dealt with silage. The first experiments with

silage in the United States were made in 1875 by Manly Miles at Champaign, Ill., when he was teaching agriculture at the University of Illinois (*131*). He stored cornstalks and broomcorn seed separately in open pits covered with straw and earth. The resulting silage was readily eaten by cattle. Much interest in the subject was created. Indication of this is seen in the presentation of a paper on The System of Preserving Green Food in Silos, by C. A. Goessmann (*74*), of the Massachusetts Agricultural College, at the annual meeting of the Massachusetts Board of Agriculture in 1880. The same year G. H. Cook, director of the New Jersey Station, reported analyses of silage from a number of places and began a silage-feeding experiment with cows.

During the early years of their operation under the Hatch Act many of the experiment stations gave attention to questions of construction of silos and preparation and use of silage as a feed. The Wisconsin Station was a leader in such work, but many others took part in it.

HORTICULTURE

In horticulture most attention was given to testing varieties, with special reference to their adaptability to different regions. Experiments with orchard fruits, particularly apples, peaches, and plums, were a leading feature of the horticultural work of many stations. Many trials of varieties of Russian apples in Iowa, South Dakota, and other North Central States were made. The self-sterility of many varieties of apples was definitely determined. In connection with its annual report for 1903 the New York State Station published a comprehensive account, with numerous illustrations, of the apples grown in New York. This account included notes on the botanical classification of apples and on the adaptation of varieties to particular regions, technical descriptions of all the varieties in the State, and a statement of their commercial importance.

Up to 1906 the stations published nearly 100 bulletins and reports on peaches, including tests of many varieties. Japanese plums were widely distributed as far north as Michigan. Nearly three-fourths of approximately 200 varieties of plums grown in this period were brought into cultivation by the stations. The California Station tested many varieties of grapes for wine and for other purposes. The Oregon Station gave much attention to prunes; a number of varieties of dates were successfully grown at the Arizona Station; the Florida Station tested varieties of citrus fruits and pineapples; and figs of different sorts were grown by the California, Georgia, and Texas Stations. Sand cherries, dewberries, Juneberries, and other native fruits were brought under cultivation. The Maine and Rhode Island Stations made experiments in growing blueberries. Many varieties of small fruits and vegetables were tested in different parts of the country. At some stations considerable attention was given to varieties of flowering plants. In 1905 the New York (Cornell) Station was growing 1,600 varieties of peonies. Pecans and other nuts were grown at some stations, particularly in the South.

Many stations undertook the improvement of varieties of fruits, vegetables, and flowers by selection and crossing. The South Dakota Station conducted large-scale breeding experiments with hardy native and foreign varieties of fruits, especially apples and plums. The Ver-

mont and Wisconsin Stations gave much attention to the breeding of plums. The effect of heat, cold, and rain on pollination of apples was studied. Efforts were made to secure varieties of peaches resistant to cold or to diseases such as yellows. At the Missouri Station an effort was made to breed out the purple color of the buds and twigs of peaches, associated with susceptibility to injury by cold. Some of the stations did careful work in selection and breeding of native varieties of grapes, persimmons, sand cherries, etc. The Rhode Island Station gave special attention to breeding raspberries and blackberries, and the New Hampshire and New York (Geneva and Ithaca) Stations did similar work with vegetables and flowers.

Pruning and grafting experiments, particularly with apples and peaches, were conducted by a number of stations in different parts of the country. The period of growth of the buds, shoots, branches, roots, and bark of apple trees was studied by the Wisconsin and Tennessee Stations. Similar work with peaches was done by the Georgia, New Jersey, and Wisconsin Stations. The Rhode Island Station investigated the effect of light on bud development, and the New York State Station studied the effect of insecticides and fungicides on the germination of pollen. Methods of controlling the ripening of wood to prevent winter-killing were also studied.

A number of stations studied the blossoming habits, winter-killing, winter protection, pruning of transplanted trees, and thinning of peaches.

Studies of soils and fertilizers with reference to the requirements of different horticultural plants were made in a number of States. As examples of this work, the Virginia Station studied the soils of the State with reference to apple growing, the Florida Station did much work on soils and fertilizers for pineapples, the Massachusetts and New Jersey Stations made special experiments with fertilizers for asparagus, the Rhode Island Station investigated the effects of lime and fertilizers on vegetables, and the New York State Station studied the influence of fertilizers on the quality of orchard fruits. The New Jersey and New York State Stations determined the amount of plant food removed from the soil by peach trees during a series of years.

In the West a number of stations studied problems in the irrigation of fruits and vegetables, as did also a few States in the humid region, notably Connecticut and New Jersey. The Wisconsin Station made important irrigation and drainage experiments with cranberries.

Experiments in orchard cultivation made by a number of stations led to improvements, especially through the application of well-known principles to local conditions. Such work included methods of planting, clean cultivation, use of cover crops, etc. The Florida Station grew pineapples under shade. The New York State Station grew strawberries and the New York (Cornell) Station grew vegetables in the same manner. The California Station made experiments in viticulture with a special State appropriation.

Greenhouse work, either as subsidiary to field experiments or for its own sake, was done at many stations. It included problems of greenhouse construction, heating and lighting, preparation and treatment of soils, use of fertilizers, irrigation, etc. The value of

subirrigation in greenhouses with certain forcing crops was demonstrated. The greenhouse work of the stations was an important factor in bringing about the winter forcing of strawberries and of certain vegetables on a commercial scale. Combinations of forcing-house and field methods of culture of a number of garden crops, notably onions, were also promoted.

The controlling factors in keeping fruit in ordinary and in cold storage were studied by a few stations. The Illinois and New Hampshire Stations made special investigations on the cold storage of apples, and the Washington Station studied the keeping qualities of fruits. The Virginia Station made a long series of studies on the utilization of unsalable fruits for jellies, jams, cider, and vinegar. There was also some work on the preservation of fruit by evaporation. The West Virginia Station made some interesting experiments on the preservation of fruit juices by pressure. Peach canning was studied by the California and Louisiana Stations.

FORESTRY

In forestry the work of the stations was principally confined to testing different varieties of trees with reference to their adaptability to particular regions, as in California, Minnesota, and South Dakota, and to studying problems connected with the reforesting of the treeless regions of the Central and Western States or of those parts of the Eastern States, e. g., in New Hampshire, Pennsylvania, and Vermont, unsuited to general agriculture.

NUTRITION OF MAN AND ANIMALS

In animal physiology the work of the stations was largely on nutrition of man and domestic animals. The most fundamental work was that connected with the construction and use of forms of the bomb and respiration calorimeters. Beginning about 1880, a modification of the Berthelot bomb calorimeter was devised at Wesleyan University, Middletown, Conn., and used in cooperation with the Storrs Experiment Station in determining the heats of combustion of a large number of different food materials. In the same way the Atwater-Rosa calorimeter was constructed and used (*181*). This is an apparatus "so arranged that a man may spend a number of days in comparative comfort within it, and so manipulated that the metabolism of both matter and energy in his body may be determined."

Experiments with living subjects in the respiration calorimeter—

> showed remarkable agreement in income and outgo of both matter and energy in the bodies of men at work and at rest, with different kinds and amounts of food, thus giving very exact indication of the ways in which food performs its functions in the body.

It was thus indicated that the law of the conservation of matter and energy holds good in the animal body. Other studies had to do with the substituting value of different nutrients and the proper combination of nutrients in the diet.

About 1900 H. P. Armsby, at the Pennsylvania Station, began the construction of a modified form of the Atwater-Rosa respiration calorimeter, in which experiments with large domestic animals could

be made. In this apparatus experiments were first made with a steer in studying the available energy of timothy hay. On the basis of theoretical considerations the conclusion was reached "that for cattle a maintenance ration is a question of tissue replacement rather than of heat production, and, therefore, that the value of a given feeding stuff for maintenance depends upon the availability of its energy" (*114, p. 536*).

Many dietary studies were made with men and animals, under different conditions and performing different amounts of work in various regions of the United States. Those with men were made in Alabama, California, Connecticut, Maine, Minnesota, Missouri, New Jersey, New Mexico, New York, Tennessee, and Virginia.

A number of stations made digestion experiments with men and animals, working out coefficients of digestibility for various American foods and feeding stuffs. In 1884 the Wisconsin Station issued a bulletin on this subject (*209*). About the same time, the New York State Station began similar work. In 1900 the Office of Experiment Stations published a bulletin (*110*), by W. H. Jordan and F. H. Hall of that station, which recorded the results of 366 digestion experiments made by different experiment stations with various feeds and animals. Among special studies of this kind were those on cassava and velvetbeans by the Florida Station, on rice bran by the Louisiana Station, and on pentosans and other constituents of the carbohydrate group in feeding stuffs and on brewers' and distillers' byproducts by the Massachusetts Station. The California Station made digestion experiments with poultry.

Many metabolism experiments were made with men and farm animals. In most of these experiments the balance of income and outgo of nitrogen was determined. In a number of experiments with men, the balance of carbon or of carbon and energy was also made. In a few cases with animals, the balance of ash or certain ash constituents was determined. The metabolism of phosphorus and sulphur in the cow and hen was studied by the New York State Station. The effect of different feeding stuffs on production of lean and fat meats, and on the strength of bones, was studied. Besides large numbers of analyses of many foods and feeding stuffs, very extended studies were made on the composition of beef, mutton, poultry, and pork from animals fattened or fed under different conditions. The effect of cooking different foods and the losses during cooking also received attention. Physiological studies of digestibility and digestive ferments and of the milk glands were undertaken. Much time was devoted to the elaboration of experimental methods, the testing of methods already known, and the devising of new methods.

ANIMAL HUSBANDRY

In the more practical fields of animal husbandry a great variety of experiments were made by the stations between 1888 and 1906. Methods of experimenting were improved, more careful and exact records were kept, the number of animals in each test was increased, and the experimental periods were prolonged. In some cases one or more carload lots of animals were fed. The Iowa Station, for example, fed from 200 to 500 steers in certain experiments, and this

station and the Wyoming Station used 250 to 300 lambs. The success of large-scale experiments by the stations greatly impressed practical stockmen and helped to bring about widespread improvements in the general practice of animal husbandry during this period.

In great part the experiments with different kinds of animals consisted of testing various combinations of feeding stuffs with reference to maintenance, growth, or the production of meat or milk. In a considerable number of cases problems of digestibility and other phases of animal physiology were also considered. As the determination of the actual nutritive value of numerous feeding stuffs in a great variety of combinations proceeded, it became evident that while the general principle of a balanced ration held good, the German feeding standards needed modification to meet the requirements of animal husbandry in this country. The stations in Wisconsin and some other States therefore undertook the formulation of feeding standards better suited to American conditions.

Stations prominent in feeding experiments with dairy cows included those in Illinois, Maryland, Massachusetts, Minnesota, New Jersey, New York, Pennsylvania, Vermont, and Wisconsin. The Illinois Station made experiments on the variations in milk due to changes in weather, season, and feed, and the extent of variations in live weight and quantity of milk and the chemical composition of milk at different stages of the period of lactation. The Maryland Station made a systematic attempt to increase the productive capacity of individual cows in a grade herd by feeding and care during a number of years. Changes in the composition of milk with advancing lactation were also studied. The Massachusetts Station made a long series of experiments on the effects of food and food constituents on the yield and quality of milk and butter. The Minnesota Station studied the causes of difference in the yield of milk by different animals under similar conditions. Protein requirements were specially studied. The New Jersey Station made experiments in the use of alfalfa, crimson clover, and other legumes in the ration of dairy cows, and studied especially the cost of the protein furnished by such crops as compared with that in commercial feeds. The New York State Station studied the sources of milk fat produced by cows under various conditions. Investigations were also made on the composition of milk as influenced by breed, age, advance of lactation, feed, etc.

The effect on milk production of substituting highly nitrogenous feeding stuffs for the more starchy feeds, to narrow the nutritive ratio, was studied by the Pennsylvania Station. The variation in the number and size of fat globules in the milk was observed from day to day. Investigations were made into the relations between the amount and composition of the food and the yield of milk and butter.

The length of feeding periods of milk cows as compared with the quantity and quality of the product; the relative feeding value of rations of essentially equal balance and of medium and wide rations; the experimental error in feeding tests; variations in the quantity and quality of milk as affected by period of lactation, environment, different foods, breeding, etc., were studied by the Vermont Station.

Rations used for dairy cows in this country as compared with the German feeding standards, the effects of warm and cold water for

cows and of long-continued feeding or withholding of salt, and the use of sorghum, rape, and silage in the ration for cows were studied by the Wisconsin Station.

A number of stations in the North Central States took a leading part in feeding experiments with beef cattle. Economy of production was the chief aim in much of this work. The Iowa Station made experiments in which the factors of breed, grade, type, sex, age, size, rapidity of growth, etc., were considered and home-grown versus purchased feeds were compared. The Missouri Station studied the economy of different feeds and nutritive ratios for young cattle and steers, and the influence of age, condition, and size of steers on beef production. The Minnesota Station tested light and heavy rations for fattening range steers and the economy of beef production from steers of different types. The Nebraska Station compared rations consisting of roughages alone or in combination with grains and protein supplements. The North Carolina Station made experiments with beef animals, in which cottonseed, hulls and meal, rice byproducts, grasses, legumes, and commercial feeds were used. The Ohio Station studied the relative economy of beef and butter production with different breeds, taking into account such factors as age of the animal and period of feeding; the fitting of range steers for market; and in a general way the relation of animal husbandry to the maintenance of soil fertility. The Illinois Station in 1903 began a study of the cost of producing beef animals from birth to maturity and investigated the market grades of such animals. The Kansas and Oklahoma Stations made special studies of the place of kafir in rations of beef animals, and the South Dakota Station compared macaroni and bread wheats and spelt with corn in a similar way. The Pennsylvania Station made technical investigations on the maintenance ration for steers. The Mississippi Station tested cottonseed and cottonseed meal in rations for steers and studied the relation of animal production to the restoration and maintenance of soil fertility. The Louisiana Station did important work on the feeding value of rice bran and molasses for beef animals. The Florida Station tested the feeding value of sweetpotatoes, cassava, and velvetbeans for steers.

Feeding experiments with calves were conducted by the stations in Illinois, Iowa, Massachusetts, Michigan, Minnesota, Nebraska, and North Carolina. For the most part these experiments related to the use of skim milk or whole milk, usually in combination with linseed meal, corn meal, or other grain. The Maryland Station compared raw, cooked, and pasteurized milk for calves and studied the effect of preservatives in milk. In some cases the experiments with calves were preliminary to those relating to the production of baby beef.

Feeding experiments with pigs were greatly expanded between 1888 and 1906. About 40 stations did more or less work of this kind. The number of pigs used in the several experiments was quite generally increased, and the feeding periods were lengthened. In a considerable number of cases the experimental period was from 150 to over 200 days. For the most part the experiments involved a comparison of different rations to ascertain the relative economy of pork productions, locally considered. The quality of the product was often taken into account, and the strength of the bones or the condition of the viscera was sometimes determined. In many ex-

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periments skim milk with or without corn meal and wheat or some of its byproducts formed the basis of comparison. But as a whole, a great variety of different feeding stuffs were compared. The most active stations in this work were those in Arkansas, Iowa, Kansas, Massachusetts, Minnesota, New York (Geneva), Oregon, Utah, Vermont, and Wisconsin.

The Kansas Station experimented with kafir and the Florida Station with cassava in the ration for pigs. The stations in Illinois, Iowa, and Kansas studied the practice of having pigs follow cattle in the feed lot. The effects of cottonseed meal on the health of pigs were studied in Alabama, Arkansas, Georgia, and Mississippi, and small amounts of this feed in the ration were used in experiments in Iowa, Kansas, New York, and Wisconsin. Some attempts were made to obtain light on the feeding ability of pigs of different breeds. In one of these studies at the New York State Station the animals were under observation from birth to the age of 39 months. At the Wisconsin Station the maintenance ration was experimentally determined for pigs weighing 50, 100, 150, and 200 pounds.

Feeding experiments with lambs, ewes, and wethers were carried on by 20 stations, 18 of which were in Northern States. A little work was done in Arizona and North Carolina, but most of it in Wisconsin. Stations in Iowa, Massachusetts, Michigan, and Minnesota made a considerable number of experiments, and somewhat fewer experiments were made at the Colorado, Connecticut (Storrs), New York (Cornell), South Dakota, and Wyoming stations. For the most part these studies dealt with the economy of production through the use of the grains, forage plants, and commercial feeds locally available to farmers. The feeding stuffs were often compounded so as to compare carbonaceous with nitrogenous rations, or wide with narrow nutritive ratios. In some cases only a few animals were used but in a considerable number of experiments there were from 50 to over 200 sheep. Some attempts were made to discover the comparative feeding value of different breeds or to compare range animals with those locally produced or purebred. Problems in the production of early lambs were sometimes investigated.

Experiments in feeding horses and mules were made by a number of stations in different parts of the country. For the most part the work was done with animals used on the farms connected with the stations. A great variety of feeds were compared. The Massachusetts Station published the record of the rations fed to horses for a number of years at the Massachusetts Agricultural College. Bulletin 125 of the Office of Experiment Stations, entitled "A Digest of Recent Experiments on Horse Feeding", contained summaries of the experiments at the stations up to 1903. Experiments in feeding a few mules, usually along with horses, were made by stations in Florida, Mississippi, North Carolina, North Dakota, Oklahoma, and Virginia.

Systematic experimenting with poultry was carried on during this period by only a few stations. The New York State Station studied the relative nutritive value and economy of a great variety of feeding stuffs and rations for hens in experiments with a number of breeds. The place of oyster shells, ground glass, grit, and sand in the diet was investigated. Ground grains were compared with whole grains and dry feed with moist. Methods of keeping eggs were tested.

Some experiments were made with ducks. The effect on egg production of separating the cock from the hens was studied. Experiments in caponizing and in feeding capons were made. The relative value of protein from animal and vegetable sources in the diet of hens was tested.

The Rhode Island Station established a poultry division in 1891 and began cross-breeding experiments of various kinds. The use of incubators and brooders was studied, as well as the heating and ventilating of brooders and houses. Experiments were made with geese, turkeys, and pigeons.

From 1895 the Michigan Station developed its poultry department and made breeding and feeding experiments with hens, capons, and ducks. About the same time the Massachusetts Station began to report experiments with breeds of hens, in which various combinations of animal and vegetable feeds were compared and wide versus narrow rations and influence of fat in the ration on egg production were tested.

From 1896 the Utah Station made experiments in breeding and feeding hens, in which the influence of age, breed, exercise, time of hatching, and different rations was studied. There were also experiments with incubators and in caponizing.

In 1898 the Maine Station began the reporting of a long series of experiments, in which efforts were made to keep an accurate record of the egg production of individual hens and to increase such production by selection and breeding. A trap nest for use in these experiments was devised at this station. The time after mating required to establish fertility in eggs was studied, as well as the relative value of different rations for egg and meat production.

The West Virginia Station made experiments on the effect of nitrogenous and carbonaceous rations for laying hens, floored versus unfloored houses, the effect of age of fowls on egg production, the influence of different feeding stuffs on the flavor of meat and eggs, the production of fertile eggs, and the use of incubators and brooders. In 1903 the Connecticut (Storrs) Station undertook the production of squabs, in addition to experiments with hens and ducks.

Other stations reporting some experimental work with poultry during this period were those in Indiana, Louisiana, North Carolina, and North Dakota, and at Cornell University.

VETERINARY SCIENCE

About half of the stations employed veterinarians or persons engaged in work in animal pathology. About 360 publications on veterinary subjects were issued up to 1906, but many of these were popular bulletins representing little, if any, investigation. Only a few of the stations were equipped for systematic original research in veterinary science. The work, therefore, consisted largely of limited observations on the nature and causes of diseases, and practical experiments in the use of methods of treatment which had not become standardized. About 20 stations did some work on bovine tuberculosis, especially making tuberculin tests. In this way many valuable facts were brought out regarding the proper use of the test and its practical application.

The Wisconsin Station went farther than any other, not only in making tuberculin tests, but in examining milk for tubercle bacilli and in experimenting on the infectiousness of milk from tuberculous cows, the control of tuberculosis by isolation of affected animals, the relation of separator slime to tuberculosis in hogs, and the thermal death point of tubercle bacilli under commercial conditions. The stations in Maine, Michigan, New Jersey, and Wisconsin studied the normal temperatures of cattle under various conditions and the relation of these temperatures to the tuberculin test. The Connecticut (Storrs) Station made a systematic experiment in feeding to calves the milk of tuberculous cows.

Tick fever of cattle, with special reference to inoculation with blood serum and the control of ticks, was studied by stations in Arkansas, Louisiana, Mississippi, Missouri, Oklahoma, and Texas. Hog cholera and methods for its control received special attention in Arkansas, Indiana, Nebraska, and South Carolina. The Delaware Station made special investigations on anthrax, and the Wisconsin Station studied tanning refuse as a source of the spread of this disease. Milk fever of cows and its relation to abortion were studied in Delaware, Iowa, Maryland, and New Jersey.

Glanders and the use of mallein for its control were investigated in Arkansas, Iowa, North Dakota, Texas, and Washington. Actinomycosis received attention in Indiana, Kansas, Michigan, and Minnesota; and blackleg in Kansas, North Dakota, and Oklahoma. Other diseases studied by one or two stations were scabies, stomach worm, and a nodular disease of sheep; "staggers", bighead, and cerebrospinal meningitis of horses; and hemorrhagic septicemia of cattle. Plants poisonous to animals, including loco weed, larkspur, *Cicuta vagans* and *C. maculata*, horsetail (in hay), grama, kafir, sorghum, and cornstalks were investigated by the Colorado, Kansas, Montana, Nebraska, North Dakota, Oklahoma, Oregon, Vermont, and Washington Stations.

Diseases of poultry were studied by the Rhode Island, Oregon, Delaware, and California Stations. Problems in dehorning, in spaying, and in relation of water supply to animal diseases were investigated by several stations.

DAIRYING

Dairying was very important in the work of the stations between 1888 and 1906. Through their work the handling of milk and the manufacture of butter and cheese were put upon a scientific basis, and practical procedures and apparatus were radically improved. Systematic investigations in dairying were carried on chiefly by the stations in Wisconsin, New York (Geneva), and Connecticut (Storrs).

An ingenious method for the rapid determination of fat in milk was devised by the chemist of the Wisconsin Station, F. G. Short, in 1888, but this was soon superseded by the method and apparatus invented by S. M. Babcock, the first account of which was published in 1890 (*15*). The Wisconsin Station also studied conditions necessary to the thorough pasteurization of milk and worked out suitable appartus for intermittent treatment of milk and cream. The increased resistance of bacteria in milk pasteurized in contact with

the air was studied. American and European dairy salts were analyzed with reference to their purity and were examined physically as to factors influencing their value for butter and cheese making. Churning experiments were also made to determine the effect of these salts on butter and its weight. The manufacture of butter from whey at cheese factories was studied. Elaborate and continuous investigation of the problems of cheese making was carried on. The nature and causes of the tainted or defective milk delivered at cheese factories were studied, and in 1896 the "Wisconsin curd test" for quickly detecting bad milk and locating its source was devised. Experiments were made in cheese ripening with temperatures from below freezing to above 70° F., which showed that temperatures between 40° and 60° gave improved quality to cheese and caused less shrinkage.

The New York State Station made many chemical and bacteriological studies of milk and its products. Methods of analysis were improved. A method of counting and measuring fat globules in milk, and apparatus for determining the viscosity of milk were devised. The causes of mottled butter, due to the action of salt on casein compounds, and the proteids of butter in relation to this condition were investigated. Much attention was given to the problems and methods of cheese making. Studies were made of the chemical composition of milk, whey, and cheese, of the relation between composition of milk and composition of cheese, and of the changes that take place in the ripening of cheese. The discovery that a considerable part of cheese ripening is due to peptic digestion led to successful substitution of pepsin for rennet in cheese making.

The Connecticut (Storrs) Station made a long series of studies on the bacteriology of milk and its products, including a determination of the species of bacteria found in dairies in the State, the organisms connected with the souring of milk and ripening of cream, the relation of lactic bacteria to other species in milk, cream, and cheese, and the conditions necessary to the sanitary production of milk. It then undertook a study of the problems involved in the manufacture of soft cheeses, especially of the Camembert type, under bacteriological control.

The Michigan Station, about 1900, began an elaborate bacteriological study of the effect of aeration of milk and of the interchange of gases between air and milk, on the oxidation, absorption, and elimination of odors and taints, on the number of bacteria, and on fermentation. The associative action of bacteria in the souring of milk was also studied.

The effect of different kinds of feed on the composition of milk or butter was studied at the stations in Illinois, Kentucky, Massachusetts, New Hampshire, and New York (Ithaca). The Maryland Station studied the initial acidity of milk and the chemical changes in milk with advancing lactation.

AGRICULTURAL TECHNOLOGY

In sugar making the Louisiana Station, at New Orleans, during all this period conducted experiments under chemical control in a well-equipped sugar house. The work included experiments in clarifying, filtering, evaporating, and cooking the juice of sugarcane, and

a series of systematic investigations with artificial mixtures to determine the restraining influence of these added substances on the crystallization of sugar. Many chemical and bacteriological studies were also made in the station laboratory. The results threw considerable light on the best methods of handling the juice; on the influence of inaccuracy in adding clarifying agents; and on the influence of the clarifying agent on the sugar, molasses, and granulation, and of clarifying methods at different stages of maturity of the cane.

Wine making under California conditions was studied by the station in that State, as were methods of preserving unfermented grape juice. Problems in the extraction of color and tannin from grapes used for wine making were investigated. Extended determinations of the nitrogen content of musts and wines showed that there is no relation between this content and quality of the wine. The keeping quality of wine was found to be dependent not upon the quantity of nitrogenous compounds present but upon their nature. This station also investigated the technology of olive oil and the pickling of green and ripe olives.

The making of cider and vinegar was studied by the Virginia Station. The work included studies of alcoholic ferments and allied forms which interfere with sound processes of fermentation, and of those fungi which impair the quality of alcoholic beverages; separation and study of yeast organisms in their relation to fermentation and the character of flavor and bouquet produced in liquor; and a practical study in fermenting the must of many varieties of native fruits. It was shown that the composition of cider can be controlled by the use of pure musts. There were also some experiments in canning fruits and vegetables.

AGRICULTURAL ENGINEERING

The principal agricultural engineering work of the experiment stations during this period was on irrigation problems. From 1898 such work was to a considerable extent carried on with the aid of Federal funds granted to the Office of Experiment Stations for irrigation investigations (p. 133). Studies relating to irrigation in regions of scanty rainfall were conducted by stations in Arizona, California, Colorado, Kansas, Montana, New Mexico, Oregon, Utah, Washington, and Wyoming. The work included investigations of the water supply from streams, reservoirs, and wells; water measurement; composition of the water; construction of earthen dams; use of pumps; evaporation and seepage from reservoirs and canals; devices for constant flow of water in laterals; duty of water in irrigation of different crops; methods of applying water; surface irrigation versus subirrigation; flooding; deep and shallow furrows; amounts of water required by different crops; times and frequency of irrigating; and special problems in irrigation of field crops, orchards, vineyards, small fruits, or vegetables.

For about 10 years problems of irrigation in humid regions were systematically studied by the Wisconsin Station, which experimented in the greenhouse and the field, on surface irrigation and subirrigation, on the use of pumps, on methods of distribution of water, and on the amount of water required for production of a pound of dry matter

and for maximum yields of different crops. Results of this work were incorporated in A Text-Book of the Physics of Agriculture, by F. H. King, published in 1901 (*111*). The Connecticut (Storrs), Missouri, New Hampshire, and New Jersey Stations studied methods of distributing and applying water to vegetables, small fruits, corn, and nursery stock in the greenhouse and the field.

A limited amount of work was done on drainage, construction of barns, greenhouses, and other buildings for experimental purposes, and on farm machinery and vehicles. The Wisconsin Station systematically investigated the form and construction of silos. The Michigan, Missouri, and South Carolina Stations studied the draft of wagons with broad versus narrow tires, and the Missouri Station investigated the effect of the height of wheels on the draft of wagons. Stations engaged in dairy work investigated different forms of milk separators and other dairy apparatus.

VERIFICATION AND DEMONSTRATION EXPERIMENTS

Much of the work of the experiment stations from 1888 to 1906 consisted of verifying the results obtained at the stations or elsewhere and demonstrating the practical usefulness of these results. This work was carried on partly at the stations, especially on the farms under their control, and partly by experiments in different localities, largely with the coöperation of farmers. This demonstration work included a wide range of subjects along most of the lines in which the stations attempted original investigations. Examples of some of the larger of these enterprises may serve to show the general character of this work.

Thousands of field trials of fertilizers were carried on in the States east of the Mississippi River. A very large number of practical tests of different field crops and horticultural plants were made by the stations in cooperation with the farmers after the stations had determined on a small scale the adaptability of these varieties to the regions in which they were located. Many experiments in feeding animals and in dairying were made by the stations for the purpose of confirming or illustrating the results obtained through previous investigations in this country or abroad. Often the chief purpose of these experiments was to convince the farmers that the results obtained elsewhere were applicable to their local requirements.

Many investigations in the fields of chemistry, botany, entomology, and veterinary science were repeated at the stations, either for the purpose of more firmly establishing the correctness of the results previously obtained or of showing the farmers that these results could be successfully applied in practice. Thus many means for repressing insect pests and the diseases of plants or animals were tried repeatedly at the stations and among the farmers until they became a part of regular agricultural practice, at least among the more progressive portion of the agricultural community.

Without doubt there was considerable duplication of work by the stations, but when we consider the wide agricultural areas for which many of the individual stations worked, the varying natural conditions in the different States, and the comparative unfamiliarity of the farmers with the results of agricultural investigations, it will be realized that incidental losses through duplication of work on the

part of the stations were more than overbalanced by the benefits which accrued from repeating investigations until their results could be made part of the general farm practice.

STUDIES OF NATURAL AGRICULTURAL CONDITIONS AND RESOURCES

Closely united with the practical experiments of the stations were those studies which had for their primary object the gaining of definite information on the natural agricultural conditions and resources of the different States. While the stations were not established for the making of agricultural surveys or the collection of agricultural statistics, yet in many cases, especially in the newer States and Territories, in the absence of accurate information acquired through other agencies, it was necessary for the stations to do more or less work of this character as a preliminary to the scientific investigations and practical experiments which it was their real business to make. In this way the stations did considerable work in collecting general meteorological data, sometimes in cooperation with the State weather services and the United States Weather Bureau. Most of this work was gradually given up and the stations confined their meteorological observations to those taken on their own grounds.

In a number of States data on the geologic formations and soils in different localities were obtained, and in a few States this was done with sufficient thoroughness to enable the station to make a soil map of the whole State or of particular agricultural regions. Studies of the nature of the water supply available for household use, for livestock, or for irrigation engaged the attention of some of the stations. A considerable number of botanical surveys were made for the purpose of obtaining information on the native forage plants and fruits of different States, that might be utilized for economic purposes. Several stations studied the life zones of their States and the suitability of varieties of crops to these zones.

The largest enterprise that may be said to have been essentially a study of the natural agricultural conditions and adaptation, was the determination of the districts in which sugar beets might be grown with a sufficiently high percentage of sugar to make it probable that they might be utilized in sugar making, provided the economic conditions were favorable. This investigation was carried on by the stations very largely in cooperation with the United States Department of Agriculture and with farmers. Thousands of experiments covering the entire country were made, and in this way the possibilities of sugar-beet growing in the United States were quite definitely established.

The marl and phosphate deposits were investigated in a number of States, with reference to their use for fertilizers where conveniently located.

In several States legislatures made special appropriations to the stations for studying the agricultural resources of particular sections as yet undeveloped, or for overcoming natural obstacles to cultivation.

INSPECTION AND CONTROL WORK

As we have seen, the early stations in Connecticut, Massachusetts, New Jersey, and North Carolina began the inspection of fertilizers. This work was strongly supported by the farmers and served a very

useful purpose. About 20 States east of the Mississippi River enacted laws for fertilizer control. The fertilizer inspection was thoroughly organized and in some respects was intimately connected with other work of the stations. Somewhat later, laws were passed for the inspection of feeding stuffs, and dairy products and other foods in Connecticut, Kentucky, Maine, Massachusetts, New Hampshire, New York, Oregon, Pennsylvania, Rhode Island, and Vermont. Inspection for the prevention of diseases of animals and plants, and for the repression of injurious insects (especially the diseases and insect pests affecting nursery stock) and weeds, was undertaken in a number of States. Dairy apparatus, and Paris green and other insecticides were inspected in a few States, and there was considerable voluntary inspection by stations in different parts of the country. The nature and extent of the inspection service of the stations differed greatly in different States.

Sometimes the station conducted a complete inspection and control; but more often it made the chemical or other examinations for some other organization which exercised the control, or it simply made the examinations and published the results for the information of the public, no system of control being provided by law. Since the Hatch Act made no provision for regular inspection work by the stations, it was necessary for the States to enact laws and provide funds for such service. In some cases, however, stations supported wholly by the Hatch fund did incidental inspection work which served to demonstrate experimentally the value and need of State legislation covering such matters.

DISSEMINATION OF INFORMATION

The Hatch Act requires that each station shall publish bulletins or reports of progress at least once in three months, and a full and detailed report of its operations, including a statement of receipts and expenditures, once a year. In the year ended June 30, 1906, the stations issued 468 publications.

In the absence of any organized extension service in the agricultural colleges the stations were obliged to do a large amount of work of this general character. Part of this was really a prerequisite to an understanding of the nature and results of their experimental work. Their publications therefore were often made up wholly or in part of compiled matter.

Most of the publications of the stations of this period may be divided into two general classes—annual reports and bulletins.

The annual reports of the stations varied widely in the character of their contents, their size, and the number of copies printed. In a number of States the annual report was a large document containing a detailed account of the investigations by the station, as well as statements on its administration and finances. In some States it was a brief document containing only short statements on administrative matters, finances, investigations, and publications. In other cases the bulletins issued by the station during the year were put in a single volume with an administrative report. In a number of States the annual report was printed at the expense of the State, sometimes by the State printer. The annual report might be sent out to the entire mailing list, thus requiring an edition of thousands of copies;

or it might have a very restricted distribution to educational institutions, experiment stations, libraries, officials, and individuals known to be specially interested in the details of station administration.

The bulletins of the stations were of different descriptions and cannot be definitely separated into classes. However, each station had a regular series of bulletins, usually numbered consecutively, which comprised the greatest part of its publications. These bulletins contained a great variety of information. Some of them consisted wholly of compiled matter, some were popular accounts of station investigations, and others were technical and elaborate descriptions of the investigations. Some stations had attempted to separate their technical and popular bulletins into different series, and in some cases new series had been begun after the station had been in operation a number of years. As a rule, however, the stations issued their regular bulletins in a single series. Illustrations were quite generally used in bulletins, and more attention had been given from year to year to improving the general appearance of the publications. Many stations annually issued more than the four bulletins required by the Hatch Act. The bulletins were sent out to mailing lists containing from 2,000 to 45,000 addresses in different States, the aggregate number of addresses being about 750,000 in 1906. The stations endeavored to send their bulletins to all applicants within their own States and to satisfy outside demands for them as far as their means would allow. Each station had a considerable number of foreign correspondents to whom the bulletins were regularly sent.

A number of the stations prepared press bulletins, which were either résumés of the station work or contained information of more general character. In cases in which the station received a large number of requests for information on any topic, it had often been found convenient to distribute answers through the press rather than by correspondence.

At the New York State Station a special officer was employed to edit the publications of the station, and one of his duties was to prepare brief popular bulletins based on the longer and more technical publications of the station. These popular bulletins were sent to the general mailing list, which, in that State, numbered 43,000 addresses, while the larger publications were issued in more restricted editions.

Some of the stations from time to time issued charts and posters illustrating special features of their work. Some of these were made up in the same manner as advertising posters, with illustrations and display type. They were placed in railroad depots, post offices, and other public places to attract the attention of farmers who were not already familiar with the work of the station, and thus to lead them to apply for the station bulletins.

The Hatch Act gave the experiment stations the right to send their publications through the United States mails free of charge.

The stations also disseminated a large amount of information through technical and popular articles; addresses by their officers at farmers' institutes and meetings of State and local agricultural, horticultural, and dairy associations and other groups of farming people; correspondence; and exhibits at State and other agricultural fairs.

MOVEMENT FOR INCREASED FEDERAL AID, CULMINATING IN THE ADAMS ACT, 1902–6

Soon after the beginning of the twentieth century the agricultural experiment stations were in a difficult situation, growing in large measure out of their success in making discoveries of practical value to agriculture and their wide dissemination of the results of their own work and of similar investigations in other countries. Favorable economic conditions were stimulating farmers to obtain and utilize the information broadcast by the stations through publications, correspondence, exhibits at fairs, and addresses at farmers' institutes and other meetings. Farmers were also encouraging their sons to take the agricultural courses at the land-grant colleges, and the enrollment of students in these courses was being greatly increased. The State legislatures were therefore easily led to make generous appropriations for buildings and equipment for the agricultural departments of these colleges. Station officers in many cases were benefited by the new and better buildings and other improved facilities for scientific work at the colleges. But, on the other hand, the greatly increased demands for their services as teachers and disseminators of information was cutting down the time and energy which they were able to devote to experimental work. In many States so much of the Hatch fund was being used for general administrative expenses, preparation and distribution of publications, and the more superficial experiments that little was left for thorough research. Even where States were making liberal appropriations for the stations, the money was often given for substations or local experiments.

In 1902 the Office of Experiment Stations called attention to the financial needs of the stations and urged that funds should be provided "for larger and more thorough experiments in many lines" (*179*).

At the meeting of the Association of American Agricultural Colleges and Experiment Stations, at Atlanta, Ga., October 7, 1902, a resolution, offered by Eugene Davenport, dean of the College of Agriculture of the University of Illinois, was adopted, instructing the executive committee, "if in its judgment it should seem expedient, to urge upon Congress at the earliest practicable date that the appropriations to the several States under the Hatch Act be increased by the sum of $15,000 annually."

The increased importance of the experiment stations was also brought out at this meeting through an amendment to the constitution of the association, offered by W. A. Henry, dean of the College of Agriculture of the University of Wisconsin, and adopted the next year, which provided for a section on experiment station work (*176*).

In the matter of increased Federal aid to the stations the executive committee was confronted with a difficult situation. There were pending in Congress bills for appropriations for mining schools or departments in the land-grant colleges, and some of the leading representatives of the land-grant colleges, including President Atherton, of Pennsylvania, a member of the executive committee, thought that the association should give first consideration to such legislation.

In June 1902 Congress passed an act authorizing the President to purchase the property and franchise of the Panama Canal Co. for

$40,000,000 and giving the Secretary of War permission to undertake the construction of the canal when the purchase had been consummated. Moreover, events growing out of the results of the Spanish War and the contemplated construction of the Panama Canal by the United States had led to a strong popular movement for strengthening the Navy, and large appropriations for this purpose were being asked. The Treasury, meantime, was facing a deficit. The management of the House of Representatives had therefore decided to oppose appropriations for new projects and especially those involving permanent Federal aid. Under such conditions the executive committee decided that it would be unwise to seek legislation for increased Federal endowment of the experiment stations in the Fifty-seventh Congress. However, they laid the foundation for future action in this direction by asking the Director of the Office of Experiment Stations to present in his next annual report a statement of the condition and work of the stations and of their need of additional funds.

In the annual report of the Office of Experiment Stations to Congress in 1903 (*180, p. 27*) it was pointed out that "by the terms of the Hatch Act, the stations are organized with a view to the investigation of problems in all branches of agriculture" and that therefore—

> a station which does not have on its staff experts representing at least ten different branches of the science of agriculture is not adequately equipped for its work. But stations whose income is confined to the Hatch fund cannot engage the full time of ten experts.

The stations had been organized broadly through their connection with the agricultural colleges and this connection permitted dividing the time of station officers between teaching and research in many cases, but with results often unsatisfactory in both lines of work.

In the same report it was shown that during the fiscal year ended June 30, 1902, of the 52 stations which shared in the benefits of the Hatch fund 25—

> were given additional State aid and 27 did not receive State aid. Of the State appropriations for the stations, six did not exceed $1,000, and only eight equaled or exceeded the Hatch appropriation of $15,000. Several of the State appropriations were exclusively for the support of substations. The total State appropriations for stations and substations were but little more than 51 per cent of the Hatch fund (*180, p. 28*).

It was also shown that in the 27 stations without State aid, after expenditures for administration, salaries, travel, libraries, publications, and permanent improvements, only about $2,645, on the average, was left for the general expenses of investigations to be divided among the station staff.

It was held that if the stations were to be continued on the broad basis on which they had been organized "they must generally be supplied with larger funds for the general expenses of investigations, in order to conduct their work in a thorough and satisfactory manner." It was stated that the work of the stations in various lines had brought out clearly the necessity for more fundamental investigations but that such investigations as a rule are costly and only a few of the stations had been able to undertake them.

Attention was called to the fact that the increased interest in agricultural education would necessitate larger State appropriations for

this purpose and would prevent many States from materially increasing the resources of their stations, but it was pointed out that—

> The results of the work of the stations are more and more depended on to furnish the materials on which courses of instruction in agriculture of different grades can be successfully based. If the nation makes the institutions of research in agriculture strong and far-reaching in their work, it will thereby lay the foundation for a system of agricultural education which, if the States and local communities do their duty, will eventually profoundly affect the material and intellectual well-being of the masses of our rural population (*180, p. 33*).

When the Association of American Agricultural Colleges and Experiment Stations met at Washington, D. C., November 17, 1903, the executive committee referred the matter of increased Federal aid to the stations back to the association "for such further action as this convention may consider advisable." A resolution offered by E. B. Andrews (*177*), chancellor of the University of Nebraska, was adopted. It instructed the executive committee "to continue the effort to secure favorable action by Congress on the mining-school bill and for increasing the annual appropriation for the experiment stations."

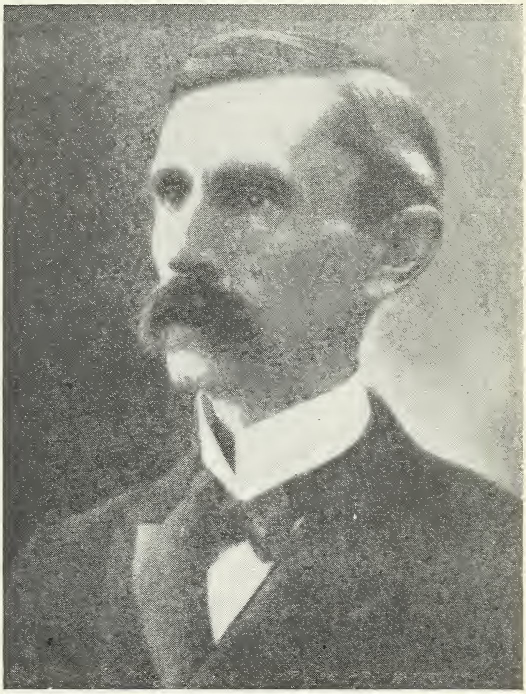

FIGURE 9.—Henry Cullen Adams, 1850–1906.

Author of the Adams Act, providing Federal funds for the support of State agricultural experiment stations.

Soon after the adjournment of the meeting of the association, November 20, 1903, Dean Henry called at the Capitol on his longtime friend, Henry Cullen Adams (*212*) (fig. 9), who was then a new Member of the National House of Representatives, to enlist his interest in securing additional Federal funds for the experiment stations.

Mr. Adams was born in Verona, Oneida County, N. Y., November 28, 1850, and went with his parents to Wisconsin the following year. He was educated at Albion Academy and the University of Wisconsin, and engaged in dairying and fruit growing. From 1883 to 1886 he was a member of the Wisconsin Legislature. From 1887 to 1889 he was active in the Wisconsin farmers' institutes. He served as president of the Wisconsin State Dairymen's Association and as secretary of the State Holticultural Society. In 1888 he was appointed super-

intendent of public property and from 1895 to 1902 was State dairy and pure food commissioner. He was elected to the Fifty-eighth Congress. In the House of Representatives Mr. Adams was a member of the Committee on Agriculture. Mr. Lever, of South Carolina, was also a member of this committee and cooperated with Mr. Adams on his experiment station bill.

On Dean Henry's representation of the needs of the experiment stations, Mr. Adams readily undertook to secure the passage of a bill giving them additional Federal aid. With the aid of the Director of the Office of Experiment Stations, a bill for this purpose was drawn (H. R. 8678), sent to Dean Henry for approval, and introduced in the House January 4, 1904, when it was referred to the Committee on Agriculture. Dean Henry and the Director of the Office of Experiment Stations (A. C. True) had laid stress on the need of funds especially for the higher forms of station work. The Adams bill was therefore so worded that the funds it provided were—

> to be applied only to paying the necessary expenses of conducting original researches or experiments bearing directly on the agricultural industry of the United States, having due regard to the varying conditions and needs of the respective States or Territories.

In view of the condition of the Treasury and the existing lack of trained agricultural investigators, the initial appropriation to each State or Territory was made only $5,000, but there was provision for an annual increase of $2,000 for 5 years, after which the amount would remain fixed at $15,000. The Secretary of Agriculture was charged with the proper administration of this law. The language of the remainder of this bill of six sections was, in the main, a mixture of phrases taken from the Hatch Act and the Morrill College Endowment Act of 1890.

After the introduction of his bill, Mr. Adams had conferences at Washington with the executive committee of the Association of American Agricultural Colleges and Experiment Stations, who, he wrote Dean Henry, "were enthusiastic over the bill and pledged me their vigorous cooperation." They, however, suggested some amendments, to which Mr. Adams agreed.

Being doubtful whether his bill would soon receive consideration in the House and desiring if possible to give the stations immediate aid, Mr. Adams, on February 5, 1904, offered an amendment to the pending agricultural appropriation bill, which would increase from $15,000 to $20,000 the amount to be given the next year to each State under the Hatch Act, but this went out on a point of order. Mr. Adams, however, was permitted to make a statement to the House on his amendment. He gave some illustrations of the practical results of the station work in Wisconsin and some other States and pointed out the relative smallness of the desired appropriation for the benefit of agriculture as compared with appropriations Congress was making for other interests.

The amended experiment station bill (H. R. 14098) was introduced March 17, 1904, and referred to the Committee on Agriculture. The principal amendments provided for quarterly instead of annual payments of the new funds, thus conforming with the Hatch Act, and permitted the expenditure of 5 percent of this fund annually for buildings or land, but made a restriction regarding "the payment of the salary of any official or instructor."

Mr. Adams secured prompt consideration of this bill by the Committee on Agriculture, and it was favorably reported to the House on March 24, 1904, by Mr. Henry, of Connecticut. The accompanying report (No. 1883, 58th Cong., 2d sess.) briefly reviewed the progress of the stations under the Hatch Act, gave illustrations of the practical results of their work, called attention to the great increase in the value of agricultural products since the stations were established, and claimed that they had "unquestionably added as much to the wealth of the United States as any educational force in the Nation."

On March 28, while the sundry civil appropriation bill was being considered in the Committee of the Whole House, Mr. Adams spoke at considerable length on his experiment station bill.

At the meeting of the Association of American Agricultural Colleges and Experiment Stations at Des Moines, Iowa, November 1–3, 1904, the executive committee reported its activities regarding both the mining school and experiment station bills and favored continuance of efforts to secure their passage. This attitude was endorsed in resolutions adopted by the association. However, the membership of the executive committee was changed by replacing President Atherton, of Pennsylvania, with L. H. Bailey, director of the New York (Cornell) Station, who was actively promoting the Adams bill. A resolution was also adopted instructing the executive committee to request a hearing before proper committees in Congress "for the purpose of promoting the work and claims of the agricultural experiment stations." Such a hearing was held before the House Committee on Agriculture on January 18, 1905.

Meanwhile Mr. Adams had continued efforts to obtain consideration of his bill by the House. On January 23, having been given full charge of his bill by the Committee on Agriculture, he began to secure signatures to a petition to the Committee on Rules to allow it to come before the House. This petition, signed by 250 members of the House, was presented to the chairman of the Committee on Rules about February 20, but without favorable result.

Before the opening of the first session of the 59th Congress, members of the executive committee of the Association of American Agricultural Colleges and Experiment Stations conferred with Mr. Adams, and an agreement was reached as to the form of the bill (H. R. 345), which was introduced in the House December 4, 1905, and referred to the Committee on Agriculture. In general, it was like the previous bill, but the restriction on the use of the funds for salaries was omitted, and it followed the terms of the Hatch Act regarding reports.

On January 15, 1906, Mr. Adams, acting for the Committee on Agriculture, made a favorable report on this bill to the House. This report (No. 242) was in general a copy of that submitted to the House on March 24, 1904, with statistics brought more nearly up to date and some additional information regarding State appropriations for the stations.

Taking advantage of a rule of the House providing that on days for the call of committees, after this had gone on for an hour, a Member might get the floor to propose other business, Mr. Adams moved that the House resolve itself into the Committee of the Whole

House for the consideration of his bill, and this was agreed to. A long debate followed, in which Mr. Adams was principally engaged in explaining the bill and answering questions regarding its details. The only amendment was proposed by Mr. Adams and consisted in changing the total annual amount to be paid each State from $15,000 to $30,000, which included the appropriation under the Hatch Act. When reported back to the House at the end of the debate the bill was passed without record vote.

It was received in the Senate February 19, 1906, and referred to the Committee on Agriculture and Forestry. Senator Proctor, of Vermont, reported it favorably from that committee on March 6, 1906. The accompanying report was mainly a copy of the report made to the House on January 15, 1906, by Mr. Adams. On March 12 the bill passed the Senate without debate, amendment, or record vote. It was signed March 16, 1906, by President Theodore Roosevelt.

Mr. Adams, by great tact and patience, had achieved a notable legislative victory through the passage of this important measure. He had long worked under a serious handicap of poor health, and died on July 9, 1906. His death caused great regret among all who understood his profound interest in agriculture and the farming people.

On April 7, 1906, the Secretary of the Treasury asked the Comptroller for an opinion on the following points: (1) Does the first appropriation under the Adams Act become available for the fiscal year 1906? (2) Is the increase of appropriation from year to year to continue up to $30,000? (3) Does this act apply to the agricultural experiment stations in Alaska, Hawaii, and Puerto Rico? The Comptroller answered the first and third questions in the negative and decided that the total amount to be paid each station under this act should not at any time exceed $15,000.

On May 1, 1906, the Secretary of Agriculture informed Senator Proctor, chairman of the Senate Committee on Agriculture and Forestry, of the Comptroller's decision and suggested an amendment to the pending agricultural appropriation bill, which would make the first appropriation under the Adams Act available for the fiscal year 1906. This amendment was agreed to by both Houses, but the appropriation bill did not pass until June 29, 1906, leaving less than 2 days for the stations to arrange for utilizing the first appropriation under the Adams Act. The Department of Agriculture ruled that this fund might be applied to any proper expenditures which had been made from March 16 to June 30, 1906, inclusive, and that bills for materials for apparatus, books, and other permanent equipment contracted for prior to July 1, 1906, might be included in the account. Four stations found it impracticable to use any of this fund, and 18 others reported unexpended balances from $2.05 up to $5,000.

On March 20, 1906, the Secretary of Agriculture (James Wilson) sent a circular letter to the directors of the experiment stations, outlining the policy of the Department with reference to the Adams fund, calling attention to the character of expenditures to which the fund is restricted and designating the Director of the Office of Experiment Stations as his representative in all matters relating to the business of the Department in connection with the administration of the

Adams Act. Each station was required to keep a separate account of the Adams fund, and a financial report made on schedules prescribed by the Secretary of Agriculture was required.

The Secretary's letter stated that—

Expenses for administration, care of buildings and grounds, insurance, office furniture and fittings, general maintenance of the station farm and animals, verification and demonstration experiments, compilations, farmers' institute work, traveling, except as is immediately connected with original researches in progress under this act, and other general expenses for the maintenance of the experiment stations, are not to be charged to this fund. The act makes no provision for printing or for the distribution of publications, which should be charged to other funds.

In order that there may be no doubt as to the disposal of the Adams fund, each station should outline a definite programme of experimental work to which it will devote this fund, and expenses for other work should not be charged to it. The work contemplated by this act will, as a rule, necessarily cover more than one year, and changes in the programme once adopted should not be made until the problems under investigation have been solved, or their solution definitely shown to be impracticable (*175, p. 67*).

"In order to avoid misunderstanding of the interpretation placed upon the act by the Department and to guard against expenditures which it might be impossible to approve at the close of the year," the Director of the Office of Experiment Stations on April 30, 1906, asked the directors of the stations to draw up definite and specific projects for the use of the Adams fund and to submit these in advance for his approval. A broad discussion followed regarding what constitutes original research in agriculture; and this subject and the general policy of the Adams Act were the most important themes discussed at the meeting of the Association of American Agricultural Colleges and Experiment Stations at Baton Rouge, La., in November 1906. The general attitude of the association was well expressed in the report of the new standing committee on station organization and policy, consisting of Eugene Davenport, of Illinois; C. D. Woods, of Maine; W. A. Henry, of Wisconsin; H. J. Waters, of Missouri; M. A. Scovell, of Kentucky; and C. E. Thorne, of Ohio. This report stated that—

The committee found itself in accord with the Office of Experiment Stations in regard to the general scope of investigations that can properly be undertaken under the Adams Act. * * *

It is evidently the intention of the Adams Act to provide the means for carrying on investigations of a relatively high order with a view to the discovering of principles and the solution of the more difficult and fundamental problems of agriculture. To this end it is very desirable that careful attention shall be given to the choice of definite problems to be studied and the methods by which the solution of these problems is to be sought. Investigations in connection with which there is good reason to expect the establishment of principles of broad application should be preferred to those which have only local or temporary importance or from which only superficial results are to be obtained (*53, p. 74*).

By general agreement the plan of conducting the work of the experiment stations on the basis of well-defined projects was inaugurated. In 1914 the Office of Experiment Stations reported that the project system as a basis for administering the work and funds of experiment stations had proved satisfactory in all respects, and its advantages were receiving more recognition each year of its operation.

The project plan was quite generally adopted to cover work conducted with whatever funds were available to the stations, though

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many of the projects were not submitted for the approval of the Office of Experiment Stations. The policy of that Office in dealing with Adams fund projects is stated in its report for 1906 as follows:

> In passing upon these projects the Office has undertaken to determine only their suitability and appropriateness under the terms of the act. It has left to the individual initiative of the station workers the planning of the investigations and the selection of the topics most important to their localities. The Office has insisted only that the projects as outlined should be such as to characterize them as scientific investigations, embracing some original features. It has not presumed to pass, except in an advisory way, upon the feasibility of the investigations, the method of procedure, or the probability of the work leading to conclusive results. While it has made many suggestions for the strengthening of the investigations, these suggestions have necessarily been advisory, rather than mandatory, since the responsibility for the planning and execution of the investigation must rest with the station worker. Every effort has been made to lead by suggestion, to inspire the spirit of investigation, and to preserve the individuality and the initiative of the investigator. * * *
>
> Research is worthy of the name only as it is directed to the answering of definite problems by scientific methods of procedure. This will involve a definite plan of operations and thorough consideration of what is known of the subject and its bearing, and should lead to a knowledge of the reasons for the results secured.
>
> Again, research presupposes a definite aim and a definite problem to be solved, a specific end to be attained rather than the mere accumulation of data. In the matter of projects the Office has insisted that this definite aim should be apparent, and that the work should be directed toward some problem or phase of a problem which would result in a contribution to our knowledge, making it less empirical and more definite. It has declined to approve plans for conducting surveys, the making of collections of and for themselves, the making of compilations and of monographs, studies of broad questions rather than specific problems or phases, the making of analyses or experiments merely to add to the general fund of data, the accumulation of observations not correlated with a definite line of investigation, the mere attempt to secure agricultural products of a superior quality without a recognition of the scientific principles involved and an attempt to add to our knowledge of them, or the conduct of experiments which add merely to our empirical knowledge but do not aim to throw light upon the fundamental principles. In a word, the effort has been made to set up the same standards for investigation and research in agriculture that are generally recognized in older branches of science (*175, p. 72*).

Undoubtedly the Adams Act has been a large factor in strengthening the scientific work of the stations and its influence has gone far beyond the use of the funds it has furnished.

HISTORY OF THE ACT ELEVATING THE UNITED STATES DEPARTMENT OF AGRICULTURE TO CABINET RANK (*174*)

The act of May 15, 1862, creating the Department of Agriculture, was a compromise measure (p. 40), which left the Department as an independent establishment with a commissioner at its head. This was not satisfactory to many of the leading farmers, especially as represented in their various organizations. The National Agricultural Congress at its meeting at Philadelphia, September 12–14, 1876, adopted a resolution asking Congress to create the office of Secretary of Agriculture (*133*). There was, however, no active propaganda for raising the rank of the Department until the mass movement of farmers, represented especially by the Grange, had gained great strength and was actively engaged in seeking legislation for the advancement of agricultural interests.

At the meeting of the National Grange, November 15–29, 1876, held at Chicago, M. D. Davis, of Kentucky, introduced the following resolutions, which were adopted:

> *Resolved*, That American agriculturists demand that they shall be recognized as a real factor in this government by the establishment of a bureau of agriculture, to be presided over by a cabinet officer, who shall organize the same upon a plan to be devised by the wisdom of Congress, which shall embrace to the fullest the agricultural interests of 20,000,000 of the people, and whose counsel and advice shall have due weight accordingly to the same on matters affecting the agricultural people and also our public affairs generally.
>
> *Resolved*, That we unite as agriculturists in one common cause to secure this object from Congress and the Chief Executive without regard to political affiliation, and that the Executive Committee are hereby instructed to send [these] resolutions to each member of the Congress of the United States, and that each State Grange prepare and sign petitions setting forth our desires for the accomplishment of this object as the very highest that can engage our common endeavors; and we do hereby earnestly call upon every Grange in the United States to give us their assistance, and every farmer and planter not a Granger, to give his aid; and furthermore, that the Executive Committee shall communicate [these] resolutions to every State Grange, and solicit the cooperation of every Grange in the United States, and that of every farmer and planter throughout the land, in such form, and manner as to them may seem best calculated to attain the object set forth herein.

From this time the National Grange and many State and local granges brought their influence to bear on Congress from year to year to bring about the elevation of the Department to Cabinet rank.

S. J. Buck, of the University of Illinois, in his book on The Granger Movement (*27*), says that—

> while the grange was of course not the very first to exert an influence in favor of this measure it seems clear that it was one of the most important factors in securing the establishment and liberal support of the Department of Agriculture.

With the decline of the numbers and prestige of the grange, other agricultural organizations became more or less prominent in this movement, notably the somewhat loosely organized Farmers' Alliance, which in the decade beginning with 1880 had at one time a following of more than a million farmers.

Undoubtedly the active participation of these great farm organizations in efforts to secure Federal legislation relating to their economic interests had much to do with their earnest desire to have agriculture represented in the President's Cabinet.

On April 21, 1879, H. L. Muldrow, of Mississippi, introduced in the House a bill (H. R. 445) to make the Department of Agriculture an executive department of the Government, and on March 4, 1880, D. Wyatt Aiken, of South Carolina, from the Committee on Agriculture, reported a substitute bill (H. R. 4909), which created the offices of Secretary and Assistant Secretary of Agriculture, provided for veterinary and entomological divisions and the collection of agricultural statistics, including—

> those relating to labor and the prices paid for the same; to the transportation and freight of agricultural products, live stock, and manufactured articles; and to the location and number of manufactures, with their sources of raw material and their markets;

and continued in force the laws relating to the existing Department of Agriculture.

Mr. Aiken, who from this time became one of the important Congressional leaders in this movement, was master of the South Caro-

lina State Grange for 2 years, and member of the executive committee of the National Grange for 6 years.

The Aiken bill was debated in the House on February 7, 1881, and was opposed by J. W. Covert, of New York, chairman of the Committee on Agriculture, as "class" legislation and therefore unconstitutional. He thought it would establish a political agency, and unnecessary offices would be created.

J. H. Reagan, of Texas, thought the bill was too narrow in scope and advocated a department of industry to care for the interests of all the industries of the country.

W. H. Hatch, of Missouri, also a member of the Committee on Agriculture, held that the bill came under the "general welfare" clause in the Constitution. Every other industry had some organization in the Government under Cabinet officers, and the fact that agriculture was such a large and varied industry made it desirable that it should have a Cabinet department.

The Aiken bill went over to the next session of Congress, in which six bills to make the Department an executive department were introduced in the House and referred to the Committee on Agriculture between December 13, 1881, and January 16, 1882.

On February 13, 1882, a bill (H. R. 4429) was reported from the House Committee on Agriculture by J. A. Anderson, of Kansas, who had been president of the Kansas State Agricultural College from 1873 to 1879. The Anderson bill provided for bureaus of agricultural products, animal industry, lands, and statistics. The bureau of lands was to "investigate and report upon the resources or capabilities of the public or other lands for farming, stock-raising, timber, manufacturing, mining or other industrial uses", and the Geological Survey was to be transferred to the Department of Agriculture.

The bureau of statistics was to—

collect and report the agricultural statistics of the United States; and, in addition, all important information or statistics relating to industrial education and agricultural colleges; to labor and wages in this and other countries; to markets and prices; to modes and cost of transporting agricultural products and live stock to their final market; to the demand, supply, and prices in foreign markets; to the location, number, and products of manufacturing establishments of whatever sort, their sources of raw material, methods, and prices; to such commercial, or other conditions as may affect the market value of farm products or the interests of the industrial classes of the United States.

On May 8 J. E. Kenna, of West Virginia, introduced a substitute bill for a department of industry, including agriculture and commerce; and J. A. Hubbell, of Michigan, from the Committee on Reform in the Civil Service, introduced a substitute bill for a bureau of mining, involving the transfer of the Geological Survey.

General debate on the Anderson bill took place in the House May 8 and 9, 1882. Those who favored the bill included Messrs. Anderson, Aiken, Muldrow, C. C. Carpenter of Iowa, W. Cullen of Illinois, and Updegraff. They dwelt on the importance of agriculture, on the demand by the Grange, Farmers' Alliance, and other agricultural organizations for a separate Department of Agriculture, and on the influence which a secretary of agriculture in the Cabinet might have on trade relations with other countries. Messrs. Kenna, Reagan, and Dunnell favored a department of industry, and the latter desired to have it include a bureau of forestry.

The Anderson bill passed the House May 10, 1882, with 183 yeas and 7 nays, and that day was received in the Senate, where it was referred to the Committee on Agriculture. It was reported back with amendments on May 29, 1882, and went over until the next session of Congress.

On January 13, 1883, Senator Plumb, of Kansas, brought up the amended bill and moved that all of the bill, after the enacting clause, be stricken out and the Department of Agriculture bill be substituted. The bill continued the divisions already existing in the Department, and added divisions of geology and animal industry. It also provided that the subordinate officers and employees, as far as practicable, should be selected without reference to their political affiliations. The bill was briefly debated January 13 and 15 by Senators Plumb, George of Mississippi, and Davis of West Virginia, who favored the bill, but it was then withdrawn, and no further consideration was given to it at this session of Congress.

On December 4, 1883, Senator George introduced a bill (S. 175) to enlarge the powers and duties of the Department of Agriculture. This bill was referred to the Committee on Agriculture and Forestry; and on February 20, 1884, that committee reported a similar bill (S. 1597).

On December 11, 1883, Congressman Aiken introduced a bill (H. R. 1457) to establish a Department of Agriculture, which was referred to the Committee on Agriculture and reported back with amendments on January 23, 1884. Further action on this bill was deferred until December 15, 1884, when it was debated in the House. Mr. Aiken gave a history of previous bills, and stated that a very large number of petitions for such a measure had been received. He asserted that such a bill was needed to deal with matters relating to exports of hogs claimed to be diseased and that it would also give character, importance, and extended jurisdiction to the existing Department of Agriculture, making it what it should be, representative of the producers of the United States.

James Wilson, of Iowa, who had come to Congress in 1883, and was a member of the Committee on Agriculture, argued that the farmers needed a Cabinet officer to represent them in foreign trade in their products, and in the making of commercial treaties.

The bill passed the House on December 15, 1883, with a vote of 166 yeas and 60 nays. On December 16, 1884, the bill was received in the Senate and referred to the Committee on Agriculture and Forestry, and on February 7, 1885, it was reported back with one amendment, but did not come up for further action.

On January 5, 1886, Senator George introduced a bill (S. 890) to enlarge the powers and duties of the Department of Agriculture. This was referred to the Committee on Agriculture and Forestry.

Between December 21, 1885, and January 7, 1886, several similar bills were introduced.

On February 3, 1886, the Committee on Agriculture reported a bill (H. R. 5190), which was a substitute for a bill introduced by Mr. Hatch, who was now chairman of the committee. In the enacting clause the Department was designated as a department of agriculture and labor. Provision was made for a Secretary and an Assistant Secretary, and the laws relating to the existing Department were continued.

A division of labor was created, which was to be under a commissioner of labor.

> The commissioner shall collect information upon the subject of labor, its relation to capital, the hours of labor, the earnings of laboring men and women, the means of promoting their material, social, intellectual, and moral prosperity, and the best means to protect life and prevent accident in mines, workshops, factories, and other places of industry. * * *
>
> The secretary of agriculture and labor shall be empowered to inquire into the causes of discontent which may exist between employers and employees within the United States, and he may invite and hear sworn statements from both such parties concerning the matters in controversy. The secretary shall make a report annually to Congress upon the condition of labor in the United States, accompanied by such recommendations as he may deem important.

This bill and various proposed substitutes and amendments were debated in the House May 6 and 13 and December 7 and 9, 1886, and January 11, 1887, and was passed in amended form by a vote of 226 yeas and 26 nays.

The Senate considered, amended, and passed the bill, which then went to conference but was not acted upon until the next session of Congress.

At the next session of Congress, Senator George introduced in the Senate, December 14, 1887, a bill (S. 784) to enlarge the powers and duties of the Department of Agriculture. In the House on January 4, 1888, Messrs. Anderson and Buchanan introduced similar bills, and on January 9, Messrs. McCreary and Hatch introduced bills to create a department of agriculture and labor. All these bills were referred to the Committee on Agriculture.

Among representatives of the farmers there was much opposition to adding a bureau of labor to the Department of Agriculture. This was voiced by Commissioner Colman, of the United States Department of Agriculture, in an address at the meeting of the National Grange at Lansing, Mich., November 22, 1887. He said that he would not favor a change in the rank of the Department "unless it could be kept for agriculture alone." Numerous petitions to Congress from State granges and the Farmers' Alliance took the same position. The effect of such influence was seen in the bill reported by Mr. Hatch, from the Committee on Agriculture, on March 7, 1888 (H. R. 8191), which was a bill to give the Department of Agriculture Cabinet rank and was drawn by simply omitting from Mr. Hatch's previous bill the parts relating to labor. It was debated briefly and passed by the House on May 21 by a vote of 236 yeas and 13 nays.

The next day the bill was brought before the Senate and referred to the Committee on Agriculture and Forestry. It was reported back with amendments May 28. There were a number of verbal amendments, and Section 5, transferring the Weather Service to the Department of Agriculture, was stricken out. The George and Hatch bills were returned to the committee on June 4, but only the amended Hatch bill was reported back to the Senate. This bill was brought up in the Senate on September 14, 1888, and was debated on that day and on 5 succeeding days. The view that the bill should be simply a measure for giving the Department of Agriculture Cabinet rank prevailed, and the bill was passed in this form by the Senate on September 21, 1888.

On February 1, 1889, Mr. Hatch submitted a conference report which asked the House to concur in the Senate amendments. Both Houses accepted the conference report, and the bill was signed by President Cleveland on February 9, 1889.

In its final form the bill was practically Senator George's bill (S. 784) of December 14, 1887, providing that "the Department of Agriculture be an Executive Department under the supervision and control of the Secretary of Agriculture" and have an Assistant Secretary of Agriculture to be appointed by the President. The laws relating to the existing Department of Agriculture were continued in force, but no additional duties were given to the Department.

With the passage of the Hatch Experiment Station Act and the act raising the United States Department of Agriculture to Cabinet rank, the organized system of agricultural research in the United States was put on a permanent and Nation-wide basis. The States were to have their own agencies of agricultural research in the experiment stations chiefly organized as departments of the land-grant colleges. These stations were to be maintained with State and Federal funds. The Nation was to have agricultural research, conducted by the United States Department of Agriculture, as part of its broad function to advance and protect the agricultural interests of the whole country.

The State and National agencies for agricultural research were to be linked together (1) by an Office of Experiment Stations in the Department of Agriculture, which was to be chiefly a clearing house for advice and information regarding the requirements, work, and results of such research in the Department, the States, and throughout the world; and (2) by an Association of Agricultural Colleges and Experiment Stations, in which the land-grant institutions and the Department of Agriculture would work together for the advancement of the general interests of agriculture and research throughout the whole country. Subsidiary organizations for the promotion of agricultural research, in existence at this time, in which the Department and State stations were also united, were the Association of Official Agricultural Chemists and the Association for the Promotion of Agricultural Science.

With the passage of the Morrill Act of August 30, 1890, for the further endownment of the land-grant colleges by grants of Federal funds, Federal and State funds were again united in the support of State institutions, and in this way, among other things, provision was to be made for the training of the scientists who in large measure were to make up the research staffs of the Department of Agriculture and the State agricultural experiment stations. Thus within the short period of three and a half years three great acts of Congress became law and fixed in a large and permanent way the general policy to be pursued in the United States regarding the maintenance of public institutions for agricultural research.

THE UNITED STATES DEPARTMENT OF AGRICULTURE UNDER THE ACT OF FEBRUARY 9, 1889, 1889–97

As soon as the Department of Agriculture became an executive department, President Cleveland appointed Commissioner Colman the first Secretary of Agriculture, and he served in this capacity until March 4, 1889.

THE ADMINISTRATION OF SECRETARY JEREMIAH McLAIN RUSK, 1889–93

There was general expectation, especially among the farming people, that the elevation of the Department of Agriculture to Cabinet rank would give it a more important place in the administration of the Federal Government and would increase its regulatory and service functions, as well as its research work, for the promotion of the agriculture of the United States. To meet this situation President Harrison selected as second Secretary of Agriculture a man who had had broad and successful experience as an administrator of public business, was a practical farmer, had the sympathy and confidence of the farming people, and was interested in scientific work for the improvement of agriculture.

Jeremiah McLain Rusk (*298, 299*) (June 17, 1830–Nov. 21, 1893), of Wisconsin, had attracted Nation-wide attention as Governor of that State, 1882–88, by his courageous handling of difficult situations growing out of labor troubles. He was born and brought up on a farm in Deerfield, Morgan County, Ohio, and in later years operated a farm at Viroqua, Wis. His formal education was confined to the common schools. While Governor of Wisconsin, he aided the development of the agricultural work of the University of Wisconsin and was particularly interested in the farmers' institutes.

Secretary Rusk decided to commit the immediate general supervision of the scientific work of the Department to some one familiar with the requirements of such work, and for this purpose the newly created office of Assistant Secretary of Agriculture was filled by the appointment of Edwin Willits (*325*) (Apr. 24, 1830–Oct. 24, 1896), who had been president of the Michigan Agricultural College from 1885. He was a native of Otto, Cattaraugus County, N. Y., moved to Michigan in 1836, graduated at the University of Michigan in 1855, and became a lawyer in 1857. He was a member of the State Board of Education from 1860 to 1872 and of the commission to revise the State Constitution in 1873. He served in the National House of Representatives from 1877 to 1883. He was a careful and conservative administrator and promoted good relations between the Department and the State agricultural colleges and experiment stations.

For the fiscal year 1893 the appropriations for the Department aggregated $2,540,080, as compared with $1,134,480 in 1889. But in 1893 the Weather Bureau had $913,060, the Bureau of Animal Industry had $350,000 aditional for control work, and the seed appropriation was $31,200 greater, leaving only $110,660 additional for the scientific and miscellaneous work. The aggregate funds used for experimental work did not materially increase during the Rusk administration. More scientific work was performed in a few lines, especially vegetable pathology and biology.

During the administration of Rusk and Willits the general plan of organization of the Department was not materially changed. The Weather Bureau, with Mark W. Harrington as chief, was added in 1891 by transfer from the Signal Service of the Army (*201*), the Section of Vegetable Pathology was made a separate division, and Divisions of Records and Editing, and of Illustrations were established. In 1891 W. O. Atwater resigned as Director of the Office of Experiment Stations and was succeeded by Abram W. Harris, the Assistant Director.

The regulatory work of the Bureau of Animal Industry, particularly that connected with the eradication of contagious pleuropneumonia, was enlarged. Divisions of inspection and quarantine were organized in that Bureau on April 1, 1891. The service work of the Weather Bureau, Division of Statistics, Seed Division, Office of Experiment Stations, and other branches of the Department was increased.

During the Rusk administration the Bureau of Animal Industry, under D. E. Salmon, sought to develop a vaccine to cure or prevent hog cholera. Its efforts were based on the belief that the so-called hog cholera bacillus was the cause of hog cholera. At times it was believed that the problem was being solved, but in the end none of these experiments was successful.

Through a long series of experiments concluded in 1891 it was proved that tick fever of cattle is caused by a microscopic protozoan parasite which attacks the red blood corpuscles. In 1889 it was first determined that this parasite attacks cattle only through the progeny of cattle ticks which have lived on infected cattle. "For the first time in history it was proved conclusively that the essential etiological factor of an infectious disease may be a microparasite that reaches its victims only through an intermediate host." The same year the life history of the tick was worked out, showing that the parasite grows to maturity on the animal to which it attaches as a seed tick.

The Division of Chemistry, under H. W. Wiley, continued investigations on sorghum as a sugar-producing plant, and also studied its value as a feeding stuff. The production of varieties with a high sugar content was undertaken at two stations in Kansas and the alcohol process for the clarification of the sorghum juice in the manufacture of sugar was also tested.

Analyses of sugar-beet samples from 1,000 localities showed that the soil and climate of a belt from 100 to 200 miles broad across the United States were favorable to the production of this crop for sugar making. On the other hand, samples from 8,000 farmers gave such variable results in sugar content that it was evident that special care and skill would be required for the successful production of beets with a satisfactory sugar content.

Attempts were made to grow sugarcane at a station on muck lands in Florida.

Investigations showing the widespread adulteration of many kinds of foodstuffs were made on a larger scale than theretofore.

The Division of Microscopy, under Thomas Taylor, supplemented the chemical studies of food adulteration by attempts to provide microscopical tests for adulteration of such substances as olive oil, cottonseed oil, lard, butter, tea, and condiments. Studies of poisonous and edible mushrooms were also made and their distinguishing features were determined and described.

The Division of Botany, under George Vasey, continued and enlarged its investigations of the native grasses and forage plants of the United States, especially those of the ranges of the Southwest. Experiments with a considerable number of species of grasses and forage plants were made at a station located at Garden City, Kans. Special publications were prepared on the grasses of the Southwest, the flora of Texas, and Mexican plants. The bulletin on the agri-

cultural grasses of the United States was revised and part I of a more comprehensive monograph on grasses was issued. Large additions were made to the National Herbarium. Weeds and their control were studied, notably the Russian-thistle, which at the time was causing great alarm among grain growers in the Northwest.

The Section of Vegetable Pathology, under the leadership of Beverly T. Galloway, rapidly developed investigations which in large measure laid the foundations of the science of phytopathology. The importance of this work was recognized in 1890 by the creation of the Division of Vegetable Pathology. One of the most significant enterprises was the 5-year series of investigations of peach yellows. These investigations, through laboratory studies and comprehensive and extensive field experimentation, cleared away some of the prevailing uncertainty about the cause and development of the disease. From 1888 to 1891 a number of papers summarizing the findings were published, and as these constituted the first comprehensive description and discussion of the disease they attracted wide attention among investigators and practical fruit growers. The practicability of controlling yellows by eradicating diseased trees from orchards was established. The southern contagious peach rosette was found to be distinct from the peach yellows but belonging to its general type.

Much valuable work was done on pear blight in California and elsewhere. Grape diseases, particularly black rot, downy mildew, anthracnose, and a California vine disease were also extensively studied. The Department initiated the study of nursery-stock diseases and carried on such studies in cooperation with the experiment station at Geneva, N. Y. Investigations of greenhouse diseases were also made. A station for the study of citrus diseases was established in Florida. Widespread experiments with Bordeaux mixture, then a new fungicide, were made and it was modified and adapted to various diseases in different parts of the country. Many other proposed fungicides, some of which the division invented, were tested on a large scale. Different kinds of spraying apparatus were also tested, and in some cases improvements were made. A notable piece of work was the devising in 1888 of an improved form of knapsack spray pump, which was widely used.

The Division of Forestry, under B. E. Fernow, continued studies of the life history of different species of timber trees and the properties of their timber, making many tests of their usefulness for practical purposes. In 1892 a bulletin on Timber Physics was published. Comparative tests of metal and wood railroad ties were made. The effect of turpentine orcharding on the longleaf pine, the influence of forests on climate, and the preparation of a check list of arborescent flora were other pieces of work. Information regarding the forests belonging to the Federal Government was collected and disseminated and helped to lay the foundation for a system of public control of these great national resources.

The Office of Fiber Investigations, under C. R. Dodge, dealt mainly with the collection and dissemination of information on flax, jute, ramie, and sisal hemp. Varieties of flax were imported for experiments, machines for decorticating ramie were tested, and attempts were made to grow sisal hemp in Florida.

The Division of Pomology, under H. E. Van Deman, examined and compared varieties of fruits sent to the Department, collected wild fruits in the West, examined citrus and other fruits in Florida, and prepared publications on wild grapes and on nuts.

The Office of Irrigation Inquiry continued and completed in 1891 the sinking of artesian wells and the study of underflow in several Western States and prepared special reports on these subjects.

The Division of Ornithology and Mammalogy, under the leadership of C. Hart Merriam, continued and enlarged its study of the geographical distribution of fauna and flora in several regions of the United States. One survey related to life zones across the country from New Mexico to Georgia. An intensive study of the Death Valley in California was made in cooperation with the Weather Bureau and the Divisions of Botany and Entomology. In 1889 a report on the English sparrow in America contained an account of this bird and its introduction into the United States, its depredations on crops, and recommendations for destroying it or preventing its increase.

The bulletin entitled "Hawks and Owls of the United States", issued in 1893, contained the results of several years' studies, and showed that for the most part these birds were not injurious to agriculture. Pocket gophers and ground squirrels in the Northwest and their relation to agriculture were also studied.

The Division of Entomology, under C. V. Riley, developed its collections of insects and the information regarding their life histories and the means of controlling or eradicating species injurious to agriculture. The Division thus became in large measure the central station to which inquiries and specimens from the State experiment stations and other sources were sent for information and for identification of species to supplement local knowledge. Many original studies of both new or nearly new species and well-known insects, were made. Among these insects were the cotton boll weevil, locusts, scale insects, pea and bean weevils, horn fly, American ox bot, gypsy moth, etc. Special efforts were made to introduce parasites of injurious insects, beginning with the successful importation of the ladybird from Australia in 1889, which led to the destruction of the white or fluted scale in California. The Division took an active part in testing insecticides and machines for their use. A notable example of such work was the experiments in California with hydrocyanic acid gas for the control of scale insects, which led to wide use by citrus growers of fumigation with this gas.

Experiments were conducted in the breeding of bees, determination of amount of honey consumed by bees in secreting a pound of wax, observations on honey plants under cultivation, evaporation of honey before its sealing by the bees, etc. Efforts to find a machine which could be economically used for reeling silk from the cocoons proved unsuccessful and this work was terminated in 1891.

The Weather Bureau was engaged principally in the developing of a Nation-wide system of weather forecasting but also undertook studies to advance the science of meteorology. In 1892, Notes on the Climate and Meteorology of Death Valley, California, and Notes on a New Method for the Discussion of Magnetic Observations were published.

This Bureau initiated the Department's work on soils by publishing in 1892 a Report on the Relations of Soil to Climate (*87*), and a bulletin on Some Physical Properties of Soils in Their Relation to Moisture and Crop Distribution (*202*).

The number and variety of the scientific and technical publications of the Department were greatly increased; Insect Life, Journal of Mycology, and Monthly Weather Review were continued, and in 1889 Experiment Station Record was begun. The first two farmers' bulletins, issued by the Office of Experiment Stations in 1889, proved so popular that the Department took over this series and made it in a large way the medium through which the practical results of its scientific work were disseminated.

THE ADMINISTRATION OF SECRETARY JULIUS STERLING MORTON, 1893–97

The Department of Agriculture was conducted in a more conservative way under the third Secretary of Agriculture, Julius Sterling Morton (*280*, *281*) (Apr. 22, 1832–Apr. 27, 1902), of Nebraska. As a student at the University of Michigan and a graduate of Union College in New York, he had early adopted the principles of so-called Jeffersonian democracy and believed that the functions of government, and particularly the Federal Government, should be kept at a minimum consistent with the maintenance of public order. Until he came to the Department he had not held public office except for a brief time as secretary and Acting Governor of the Territory of Nebraska. He was born at Adams, Jefferson County, N. Y., moved to Michigan in 1834 and to Nebraska in 1854. There he aided in the foundation of Nebraska City. He took up land near that city, on which he established a home and made an estate where field crops, livestock, and apples were grown, but primarily for ornamental and educational purposes. He was impressed with the importance of planting trees on the prairies for wood supply and for the ornamentation of homesteads and towns. To encourage this he became the author of the Nebraska Arbor Day legislation which provides an annual public holiday to be devoted to tree planting. This plan was adopted in many States and gave him a national reputation as a promoter of forestry. He was one of the original members of the Nebraska Territorial Board of Agriculture and of the horticultural society and was president of both of these organizations.

He had the characteristics of a man who spent his life largely as a writer on political economy and as a member of the opposition in political life. He was never convinced that the Department of Agriculture should have a large place in the Federal Government but desired that whatever it did should be done systematically and thoroughly and that its scientific work should be of a high order and thoroughly divorced from political influence. He respected the opinions of Department officers who differed with him on questions of policy and were courageous in maintaining their ground in discussions, but on the other hand he was sometimes moved by personal likes or dislikes in dealing with individuals.

Edwin Willits (p. 178) continued to be Assistant Secretary of Agriculture until the end of 1893. This arrangement was made in order that he might complete his work as chairman of the Government

Board for the Columbian Exposition at Chicago. His successor was Charles W. Dabney (p. 90), president of the University of Tennessee. His training as a chemist and his experience as experiment station director and land-grant college president fitted him in unusual measure for the supervision of the scientific work of the Department in continuance of the policy initiated by Secretary Rusk. His attractive personality won the cordial support of Secretary Morton in increasing measure as his work developed, and his generous attitude toward Federal support of scientific work related to agriculture favorably offset to a marked degree the attitude of Secretary Morton toward limiting appropriations and expenditures for the Department's enterprises.

During Secretary Morton's administration there was no increase in the total annual appropriations for the Department, and out of an aggregate of $11,179,455 appropriated from 1893 to 1897 more than $2,000,000 was not expended. Nevertheless, the annual sums spent for scientific work were somewhat increased (*47*). This was particularly true with regard to soils, grass and forage plants, and forestry. Studies of road problems were begun. The Secretary himself obtained appropriations for investigations in human nutrition. The Library also received increased attention. In spite of the Secretary's decided and widely published opposition, Congress increased the annual appropriation for seed distribution to $150,000. In his report for 1896 Secretary Morton asserted that over $1,700,000 out of a total appropriation of $2,584,000 for that fiscal year was spent on the technical and scientific work of the Department, in which about 1,000 persons were employed.

In the Weather Bureau, investigations on soils in relation to meteorology were undertaken with Milton Whitney in charge, and in 1894 a separate Division of Agricultural Soils was established, of which he was Chief. Willis L. Moore succeeded Mark Harrington as Chief of the Weather Bureau on July 1, 1895.

In the Division of Botany work in agrostology was begun under F. Lamson-Scribner, and on July 1, 1895, a Division of Agrostology was organized under his direction. The National Herbarium was transferred to the Smithsonian Institution in July 1896, with the Chief of the Division of Botany as honorary curator. F. V. Coville succeeded George Vasey as Chief of the Division of Botany in March 1893.

The Divisions of Records and Editing and of Illustrations were combined in the Division of Publications in 1895.

The Division of Microscopy was abolished July 1, 1895.

A Dairy Division was established in the Bureau of Animal Industry July 1, 1895, with H. E. Alvord as chief.

Henry A. Robinson succeeded J. R. Dodge as statistician March 20, 1893.

Samuel B. Heiges succeeded H. E. Van Deman as Chief of the Division of Pomology in 1893.

W. P. Cutter became Department librarian August 28, 1893.

A. C. True (*314*, *315*) succeeded A. W. Harris as Director of the Office of Experiment Stations September 26, 1893.

The regulatory, service, and publication work of the Department continued to expand during Secretary Morton's administration. In 1896 the Department issued 376 publications. In 1894 the publication of the Yearbook was begun. Under the act of January 12, 1895, the edition of publications exceeding 100 pages was limited to 1,000 copies. The act of June 12, 1895, created the office of Superintendent of Documents, who was given authority to sell publications issued by the Government.

On November 1, 1896, the Department had 2,217 employees, a reduction of 280 since March 4, 1893. This reduction was to a considerable extent brought about by doing away with the employment of temporary field agents. Secretary Morton was a strong believer in the merit system for the Civil Service, with the result that 1,657 positions were subject to competitive examination near the end of his administration, as compared with 606 at its beginning. All the chief officers of the Department were included in the classified service, except the Secretary, Assistant Secretary, and Chief of the Weather Bureau, who were appointed by the President.

The Weather Bureau undertook the development of means and appliances for sustaining meteorological instruments at high altitudes. Kites were used in making observations up to 7,000 feet. Reports were made on the climatology of the cotton plant and on the relative humidity of southern New England and other localities with reference to spinning and weaving cotton. Studies of the relation of solar magnetism and meteorological phenomena were continued.

The Bureau of Animal Industry continued the study of tick fever and made many experiments with destructive agents against cattle ticks. Considerable progress was made in investigations on the diagnosis and control of tuberculosis. The infectious diseases and tapeworms of poultry were studied. Investigations were made on the morphology, biology, and pathology of bacteria found in various animal diseases.

The Division of Chemistry emphasized the study of the composition and adulteration of foods and made examinations of many different products. Pot experiments with soils and fertilizers included both chemical and bacteriological studies. The chemical and physical characteristics and activities of nitrifying organisms were investigated. Work on sugar beets, sorghum, and sugarcane was continued.

Among the numerous investigations made by the Division of Entomology during Secretary Morton's administration were those on the San Jose and other scale insects, citrus fruit insects, and those affecting domestic animals. Studies on the cotton boll weevil, found in Texas in 1894, were begun. Many insecticides and machines for insect control were tested, and the effect of insecticides on foliage was studied. Monographs were issued on flies, parasitic insects, and household insects.

The Division of Botany continued investigations on a large number of grasses and forage plants in the subarid regions and the Southern States. This work was continued and expanded in the Division of Agrostology. Studies of weeds and poisonous plants were continued.

The Division of Vegetable Physiology and Pathology continued to be very active in both laboratory investigations and field experiments on the nature, causes, and control of numerous plant diseases. Diseases of city trees and the greenhouse diseases of flowers and lettuce were given special study. Much work was done on the improvement of spray machinery, the times of application of fungicides, and tests of new fungicides. The chemical and physical properties and toxic effects of Bordeaux mixture were investigated. Pollination studies of numerous varieties of pears and apples showed that the majority were incapable of self-pollination.

The Division of Forestry continued studies and tests of the strength and other qualities of timbers of different species. Studies of southern pines were made. The rate of growth of white pine trees was investigated. Work on the nomenclature of arborescent flora was continued. Experimental planting of forest trees was made in cooperation with the experiment stations in Colorado, Kansas, Nebraska, and South Dakota.

The Office of Fiber Investigations continued studies on flax, jute, ramie, and hemp, publishing reports on uncultivated bast fibers, the tillage and manufacture of ramie, and the growing of jute and hemp in the United States. Experiments with flax were made in Minnesota and Washington.

The Division of Pomology continued the collection, description, and modeling of varieties of fruits and nuts, giving much attention to varieties of apples.

The Division of Ornithology and Mammalogy (Biological Survey) continued studies of the geographic distribution of plants and animals and by 1894 had covered 25 Western States, 3 Southern States, and Pennsylvania. The food habits of birds of many kinds were investigated, and reports were issued on kingbirds, woodpeckers, and blackbirds.

The Office of Irrigation Inquiry collected considerable information on the laws and practice of irrigation in several Western States.

The Office of Road Inquiry, established October 3, 1893, began a study of the methods of road making.

The Office of Experiment Stations, under special authority from Congress, undertook in 1894 an annual inspection of the State agricultural experiment stations and greatly increased its advisory functions regarding their management, personnel, and equipment. It also enlarged the review of foreign agricultural investigations in Experiment Station Record. The supervision of the appropriations for nutrition investigations, begun in 1894, was entrusted to this Office. W. O. Atwater was special agent in charge, with headquarters at Wesleyan University, Middletown, Conn. The work was carried on in cooperation with colleges, experiment stations, and other organizations in different parts of the country. It included studies of the composition and nutritive value of different foods, singly and in combination, dietary studies, digestion experiments, determination of the effect of cooking on nutritive value, and the construction of improved forms of the bomb calorimeter and the respiration calorimeter.

LARGE DEVELOPMENT OF RESEARCH RELATING TO AGRICULTURAL PRODUCTION, 1897–1913

UNITED STATES DEPARTMENT OF AGRICULTURE

ADMINISTRATION OF SECRETARY JAMES WILSON, 1897–1913

James Wilson (*326*, *327*) (Aug. 16, 1835–Aug. 26, 1920) (fig. 10), of Traer, Iowa, became Secretary of Agriculture on March 5, 1897, and served during the administrations of Presidents McKinley, Roosevelt, and Taft, a term longer than that of any other Cabinet officer in the history of the United States. He was born on a livestock and dairy farm in Ayrshire, Scotland. He came with his family to the United States in 1852. They settled first in Connecticut but in 1855 moved to what is now Tama County in central Iowa, where they successfully followed substantially the same type of farming as in Scotland, producing and selling high-grade livestock and dairy products and consuming their crops on the farm. James attended local schools and for a short time Iowa College, but largely educated himself by studying agriculture and general history. In 1861 he obtained a farm of his own, which in after years was much enlarged. There he gave special attention to feeding livestock, having early seen the advantage of growing purebred animals.

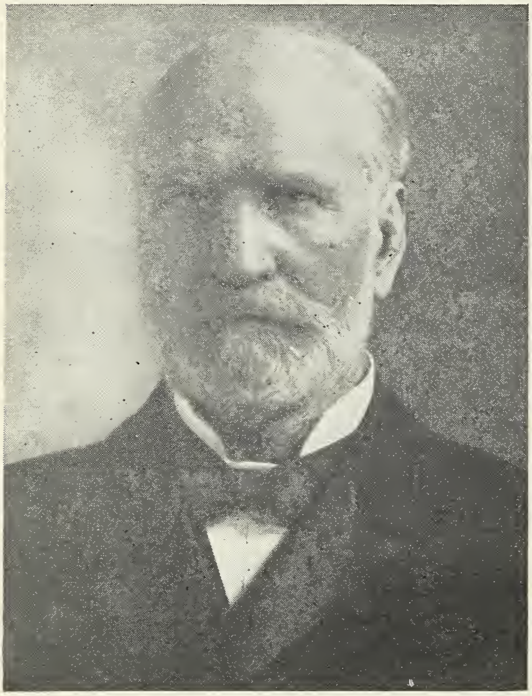

FIGURE 10.—James Wilson, 1835–1920.

Secretary of Agriculture, 1897–1913; during whose long administration there was a notable development of the United States Department of Agriculture.

In 1867 Mr. Wilson was elected to the Iowa Legislature and served there three terms, in the last of which he was Speaker. On issues growing out of the transportation difficulties of that period he was elected to the National House of Representatives and served there from 1873 to 1877, and again from 1883 to 1885, having meanwhile been a member of the Iowa Railway Commission. In Congress his knowledge of parliamentary rules and practice gave him an important place in its committees and proceedings.

After retiring from Congress he undertook the writing of weekly letters on agricultural subjects, which were published in about 50

county papers. He also helped to organize the Iowa Improved Live-Stock Breeders' Association and served as a regent of the Iowa State University. From 1890 to 1897 he was professor of agriculture and director of the agricultural experiment station at the Iowa State College of Agriculture and Mechanic Arts at Ames. There he greatly stimulated teaching and experimental work in agriculture and built up an agricultural faculty.

Combining great native ability with keen judgment of people and affairs, he was unusually well fitted for the Secretaryship of Agriculture by his experience as a farmer, educator, member of legislature and Congress, and by his great interest in the promotion of agriculture through legislation, experimentation, education, extension work, and the dissemination of agricultural knowledge through public and private literature. Farmers throughout the country felt that he thoroughly understood their work and life and would do all he could to advance their interests. He was also well acquainted with the mind of Congress and knew how to present most effectively to its members the work and the needs of his Department. He was very desirous that the Department and the agricultural colleges and experiment stations should grow and flourish and believed that they should have generous Federal support.

His great interest in both the scientific and practical work of the Department and his experience at the Iowa Agricultural College and Experiment Station led him to desire to follow closely the activities of all the divisions of the Department. For this reason he changed the previous policy regarding the assignment of duties to the Assistant Secretary of Agriculture and kept the supervision of the scientific work of the Department in his own hands.

From March 22, 1897, to his death, Joseph Henry Brigham (*228*) (Dec. 12, 1838–June 29, 1904) was Assistant Secretary of Agriculture. He was born at Lodi, Ohio, and was educated in the common schools, with one term each at Berea University near Cleveland and the normal school at Lebanon, Ohio. After serving in the Civil War he engaged in farming in Fulton County, Ohio. Having been elected to the State Senate in 1880, he secured the passage in 1882 of a bill establishing the Ohio Agricultural Experiment Station. In January 1882 he was elected a member of the State Board of Agriculture; in 1887 he was appointed a member of the board of trustees of Ohio State University, and from that year to 1894 was a member of the board of control of the Ohio Experiment Station. He joined the Patrons of Husbandry in 1873, served several years as master of the Ohio State Grange, and from 1888 was for 10 years master of the National Grange. As representative of the Grange he was active in promoting the passage of the Hatch Experiment Station Act in 1887 and the Morrill Land-Grant College Act of 1890.

While in the Department of Agriculture, much of his time was spent as chairman of the Government Board at the National Expositions at Omaha, Nebr., Buffalo, N. Y., Charleston, S. C., St. Louis, Mo., and Portland, Oreg.

On December 19, 1904, Willet Martin Hays (*256*, *257*) (Oct. 19, 1859–Jan. 15, 1928), of Minnesota, was appointed Assistant Secretary of Agriculture. He was born in Hardin County, Iowa, and educated at Oskaloosa College, Drake University, and Iowa State College, re-

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ceiving from the latter the degrees of Bachelor and Master of Agriculture in 1885 and 1896. He was assistant professor of agriculture there in 1886, and professor of agriculture at the University of Minnesota and agriculturist of the Minnesota Experiment Station from 1888 to 1891, held similar positions at the North Dakota Agricultural College in 1892 and 1893, and again at the University of Minnesota from 1894 to 1904. He made a specialty of the breeding of field crops and was broadly interested in the breeding of plants and animals and in secondary and elementary education in agriculture. He published a book on Rural School Agriculture in 1903 and one on Breeding Plants and Animals in 1904. He was agricultural adviser to the Argentine Minister of Agriculture in 1913 and to the University of Tucuman in 1914. Afterwards he engaged in farming at West Chester, Pa.

During his connection with the Department of Agriculture he gave much time to the promotion of Federal aid for secondary vocational education and agricultural extension work and to the Nelson Amendment of 1907, which increased the Federal funds given to the land-grant colleges. In 1900 he organized the American Breeders Association, which later became the American Genetics Association.

Various general conditions in this country and abroad made the period of Secretary Wilson's administration favorable for the great expansion of the work of the Department of Agriculture. Internal commerce and manufacturing in the United States were generally prosperous and greatly expanding. The great railroad systems were pushing out into many new regions in the West and needed more crops and livestock for transportation. Population was increasing rapidly throughout the country. Great hordes of immigrants were concentrating in the industrial centers, particularly in the East, and needed cheap food, clothing, and shelter. Business and labor were therefore in favor of liberal appropriations to stimulate agricultural production. Industrial expansion was also proceeding rapidly in Europe, and there was increased demand for American meat, grain, and cotton.

Farm land in the great agricultural regions of the United States was increasing in value, and the farmers there desired larger production per acre. Land values and crops were declining in the old agricultural regions of the Northeast, and farmers there needed advice and help. Agriculture was spreading over the Great Plains, the western mountain areas, and the Pacific coast, and was revealing many problems in dry-land farming and irrigation. The country was beginning to awaken to the rapid depletion of its forest resources under private exploitation and was seeking State and Federal control of this situation. The prosperity and in some places almost the existence of agriculture were being menaced by the increasing number and virulence of plant and animal pests, both native and foreign.

Meanwhile the Department of Agriculture and the State agricultural colleges and experiment stations had already shown very useful results from the expenditure of relatively small funds for agricultural education, research, and extension work. Foreign work in similar lines was also accumulating a great fund of useful information about which the people of the United States needed to know more. For these and other reasons business men, laborers, and farmers, in

great numbers and through their numerous organizations, were declaring in favor of having more Federal money spent for agricultural research, extension work, and publications. This demand grew in almost geometric proportion as the Department demonstrated its ability to give good returns for the funds at its disposal; and under such a leader as Secretary Wilson, Congress responded to its askings in a most liberal way.

The appropriations for the Department increased from $3,272,902 for the fiscal year ended June 30, 1898, to $24,742,044 for the fiscal year 1913.

The only large building project undertaken during Secretary Wilson's administration included the planning and partial erection of a structure on the south side of the Department grounds, intended

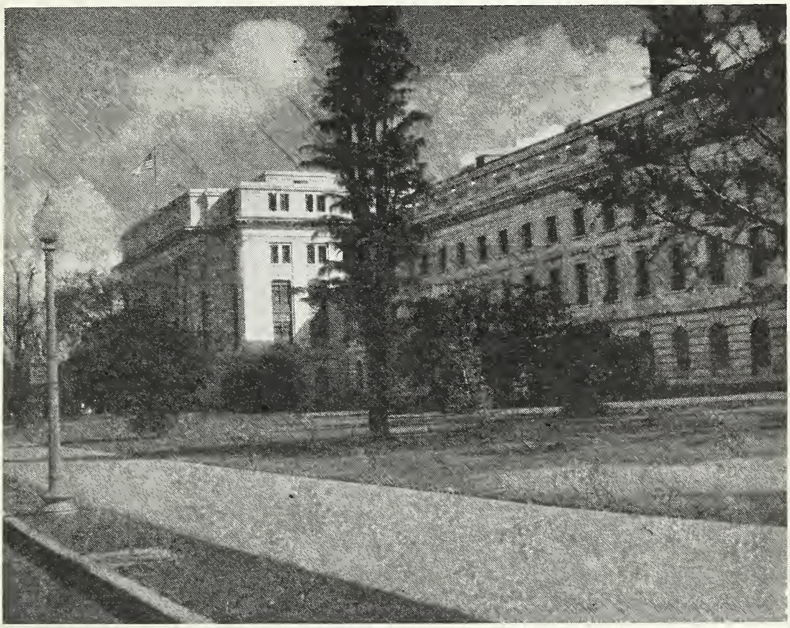

FIGURE 11.—New main building of the Department of Agriculture, completed and occupied in 1930.

when completed to be a monumental edifice worthy of the great interests of agriculture in the National Capital. The original plans were drawn by the architects Rankin, Kellogg, and Crane, of Philadelphia, and were approved by the building committee of the Department, consisting of B. T. Galloway, D. E. Salmon, and A. C. True. This committee also had general supervision of construction of the two laboratory wings of this building, which were its more urgently needed parts and for which the appropriation of $1,500,000 available was only sufficient. The wings were completed in 1908 but housed only part of the force engaged in scientific work of the Department. Congress later provided for the erection of the central portion of the building, as part of a general plan for Federal buildings in the District of Columbia (fig. 11).

In 1901 the Arlington Farm, a tract of over 300 acres on the Virginia side of the Potomac River opposite Washington, was added to the material equipment of the Department.

A farm of 475 acres at Beltsville, Md., was bought in 1910 for the use of the Bureau of Animal Industry for investigations in animal husbandry and dairying.

Beginning in 1903 a meteorological observatory was established at Mount Weather, 1,800 feet above sea level on the Blue Ridge range in Virginia, about 50 miles from Washington. Several buildings were erected and equipped there.

The number of persons on the payroll of the Department in 1897 was 2,444. Ten years later it was 9,107, and on July 1, 1912, it aggregated 13,858. Table 4 shows the increase of personnel in the different bureaus and offices.

TABLE 4.—*Number of employees in Department of Agriculture 1897 and 1912*

Department unit	1897	1912	Department unit	1897	1912
Weather Bureau	[1] 1,000	2,051	Bureau of Biological Survey	23	97
Bureau of Animal Industry	777	3,311	Bureau of Statistics	133	162
Bureau of Plant Industry	127	2,128	Office of Public Roads	7	163
Forest Service	14	4,127	Office of Experiment Stations	38	209
Bureau of Chemistry	20	546	Library	6	29
Bureau of Soils	33	159	Division of Publications	61	188
Bureau of Entomology	21	339	Division of Accounts	10	66

[1] Approximate number.

In 1913, in addition to the bureaus and offices already mentioned, there were the Library, Division of Publications, Division of Accounts and Disbursements, Supply Division, and the offices of the Chief Clerk and Appointment Clerk.

The policy of keeping within the classified civil service practically all the scientific, technical, and clerical employees of the Department, including the chiefs of bureaus and offices, except the Chief of the Weather Bureau, who is by law appointed by the President, was well maintained during Secretary Wilson's administration. This led to a large measure of permanence in the personnel of the Department in all its grades. The Chiefs of the Weather Bureau, Bureaus of Plant Industry, Entomology, and Soils, and the Office of Experiment Stations remained throughout Secretary Wilson's administration, the Chief of the Bureau of Chemistry until 1912, and Chiefs of the Forest Service and Bureau of Biological Survey until 1910. When positions of Chief of the Bureau of Animal Industry, Division of Publications, and Division of Accounts and Disbursements became vacant within this period, experienced employees in these respective units were promoted to fill them.

The scientific work of the Department of Agriculture up to and during Secretary Wilson's administration revealed the desirability of Federal control of legislation in a number of matters affecting the agriculture and the health of the United States.

This development of Federal legislation had begun with the so-called Twenty-eight Hour Act of March 3, 1873, which was intended to prevent cruelty to animals while in transit in interstate commerce by requiring their unloading for rest and feeding after being on the

cars not more than 28 hours. Court decisions having seriously narrowed the operation of this act, Congress adopted recommendations of the Department by passing an amended act of June 29, 1906, which was much more complete and satisfactory.

An act of August 30, 1890, provided for inspection of salted pork and bacon intended for exportation to foreign countries, but did not require post-mortem inspection at the time of slaughter. This was superseded by an act of March 3, 1891, which required the Secretary of Agriculture to cause an ante-mortem inspection of all cattle, sheep, and hogs intended for interstate commerce and post-mortem examinations of such animals when deemed advisable. When it was widely charged that the packing houses of the country were not conducted in a sanitary manner, Congress adopted recommendations of the President and of the Secretary of Agriculture and passed the Meat Inspection Act of June 30, 1906, which enabled the Bureau of Animal Industry to inspect the preparation of meat-food products intended for interstate commerce and mark them to show that they had been inspected.

The Lacey Act of May 25, 1900, prohibited (1) the importation into the United States of animals and birds which were ascertained by the Department to be destructive to crops and poultry, and (2) interstate commerce in game killed in violation of State laws. This was strengthened in 1909 by an amendment which forbade the shipment of game killed in violation of local laws.

An act of February 2, 1903, authorized the Secretary of Agriculture to establish rules and regulations for the exportation and transportation of livestock between the States and foreign countries where he had reason to believe livestock diseases existed. He was also empowered to seize, quarantine, and dispose of any hay, straw, forage, or similar material, or any meats, hides, or other animal products coming from an infected foreign country or moving from one State to another, whenever he judged such action advisable in order to guard against the introduction or spread of livestock contagion. Difficulties having arisen in the administration of this act, Congress adopted the recommendations for a more comprehensive law by passing the act of March 3, 1905, which gave the Secretary power to quarantine any State or Territory, or portion thereof, where contagious, infectious, or communicable livestock diseases were found to exist.

The creation of national forests in the public domain was first authorized by an act of March 6, 1891, and jurisdiction over them was conferred upon the Secretary of the Interior by an act of June 4, 1897. This jurisdiction was transferred to the Secretary of Agriculture on February 1, 1905, and the number and extent of such forests were increased from time to time, until in 1913 the Forest Service had the management of nearly 200,000,000 acres. The growing conviction of the Department foresters that timbered lands in the East should be acquired by the Government to conserve and promote the navigability of streams in and contiguous to the Appalachian Mountain Range led Congress to follow the Secretary's recommendations to this end and to pass the Weeks Forestry Act of March 1, 1911, under which private lands in that region have been purchased and made national forests.

As the result very largely of the analytical work of the Bureau of Chemistry covering several years, which showed widespread adultera-

tion and misbranding of foods and drugs passing in interstate commerce and imported from foreign countries, Congress passed the Food and Drugs Act of June 30, 1906, which enabled the Department to fix and enforce standards of purity for a great variety of such products.

The Insecticide and Fungicide Act of April 26, 1910, follows in substantial form the provisions of the Food and Drugs Act and is intended to suppress interstate commerce in adulterated and misbranded insecticides and fungicides.

The Plant Quarantine Act of August 20, 1912, in its general scheme follows the Livestock Quarantine Act of 1905 and assists the Department of Agriculture in controlling plant diseases and parasites coming into the United States, as well as those existing here.

A considerable portion of the Department's funds have always been used for what is often called service work, based in part on scientific research. This work very greatly increased during Secretary Wilson's administration. Among the more important enterprises of this kind were the following:

The Weather Bureau issued daily weather forecasts, based on observations at 193 stations in 1912 as compared with 131 stations in 1897. To these were added the warnings regarding storms, hurricanes, and cold waves, and the river and flood service. This work was of advantage to commerce, manufacturing, and citizens generally, as well as to agriculture.

The Bureau of Animal Industry extended its distribution of tuberculin from 57,000 doses in 1897 to 329,000 doses in 1912, and of mallein for control of glanders from 1,400 to 135,000 doses in the same period.

The Bureau of Plant Industry carried on and enlarged seed and plant distribution and did considerable testing of the purity and vitality of seeds sent in for examination.

The Bureau of Soils developed a comprehensive soil survey, which included much information about general agricultural conditions, and which covered 622,595 acres in 12 years.

The Forest Service gave much advice on forest management to private owners of woodlands, covering 1,000,000 acres in 1898 and nearly 11,000,000 acres in 1905.

The Bureau of Entomology identified large numbers of insects sent in by colleges and experiment stations, in addition to strengthening various lines of economic entomology.

The Bureau of Statistics amplified its system of monthly and special crop reports, increasing the number of its voluntary correspondents to about 135,000.

The Office of Public Roads (*94*), from 1905, tested many road materials, on the basis of similar work begun in the Bureau of Chemistry in 1900.

The Office of Experiment Stations continued and enlarged its service work, which included preparation of Experiment Station Record and organization lists of the agricultural colleges and experiment stations, promotion of agricultural education and farmers' institutes, compilation of irrigation laws and effort to improve such legislation, collection and publication of information on irrigation conditions in a number of States, and drainage surveys and plans covering large tracts of wet lands in various parts of the country.

Extension work by the Department was greatly increased during this period. This included continuance, under a liberal policy, of addresses by the Secretary, Assistant Secretary, and representatives of the different bureaus and offices at colleges, schools, farmers' institutes, and meetings of agricultural and educational associations. Exhibits of various phases of the Department's work were made at State and other fairs, and more comprehensively at the great national expositions. There was also a growing use of field and other practical demonstrations of improved methods and processes.

The Bureau of Entomology demonstrated methods and apparatus for the control of bark beetles injuring forest trees, the codling moth, the pear thrips in California, the grape rootworm in Pennsylvania, the cotton boll weevil in Texas, the cattle tick in Texas, the plum curculio in Georgia, and other insects elsewhere. Much of this Bureau's effort to prevent the spread of the gypsy moth and brown-tail moth in the Northeastern States was extension work.

The Bureau of Animal Industry, through its Dairy Division, did much to develop and improve dairy husbandry in the South and far West, promote cow-testing associations, introduce the score-card system for improving market milk, and to aid organization and management of creameries and cheese factories.

The Office of Public Roads constructed hundreds of small pieces of road to demonstrate the use of different materials and methods in road making.

The Bureau of Plant Industry conducted numerous field demonstrations of treatment for prevention or control of plant diseases by the use of fungicides, special spraying apparatus, or otherwise. Diseases of the grape and the potato received special attention. It also established demonstration farms to show improved methods of farm management. When the ravages of the boll weevil in Texas and its threatened spread to other Southern States alarmed the cotton growers, this Bureau developed a system of field demonstrations of improved practices by farmers on their own farms. With the financial aid of the General Education Board and liberal Federal, State, and local appropriations, this developed between 1904 and 1913 into a unique and widespread extension system in all the Southern States, involving the employment of men and women as State, district, and county agents, the organization of clubs for adults and children, and the conducting of many thousands of demonstrations on farms and in homes.

In 1910 the county agent system began to be introduced in the Northern States through the influence of the Office of Farm Management, and, with the cooperation of agricultural colleges and farm and business organizations, spread rapidly there.

The number and variety of the scientific, technical, and popular publications of the Department reflected the growth of its organization and work. In 1897, with a printing fund of $116,888, the Department publications numbered 424 and aggregated 6,541,210 copies; in 1912, with $470,000, a total of 34,678,557 copies of 2,110 publications were printed. The new publications that year numbered 1,462, of which 44 were farmers' bulletins. Many of the bulletins in this popular series were reprinted, and the total editions of new and old bulletins of this class in 1912 aggregated 11,000,000 copies.

The Department Library grew between 1897 and 1912 from 59,000 to 122,000 books and pamphlets. It thus became "the largest collection of literature in this country on agriculture and related sciences, and as far as known the largest agricultural library in any country." Besides a large amount of American literature, it had the largest and most complete collection in the United States of foreign agricultural books and periodicals, together with publications of foreign agricultural institutions, societies, and experiment stations. Nearly 2,000 periodicals were being received currently in 1912.

Whereas only a comparatively small portion of the Library had been cataloged by 1897, the dictionary catalog in 1912 contained about 286,000 cards. In 1899 the issuance of a printed card catalog of the publications of the Department was begun, and in 1902 this was the first department library to cooperate with the Library of Congress in printing catalog cards of its accessions.

The experimental and research work of the Department of Agriculture very greatly increased in variety and extent during Secretary Wilson's administration. In its general range it extended from search for plants and animals suitable for use in this country, and simple tests of varieties of plants, fertilizers, and methods of cultivation, to elaborate studies of problems in plant and animal biology and physiology, the laws of human nutrition, the relation of insects, fungi, and bacteria to plant and animal diseases, and the chemistry, physics, and bacteriology of soils. Most of this work related to agricultural production, but studies in the field of agricultural economics, including marketing and farm management, were begun, particularly in the later years of this period. The experimental operations of the Department dealt not only with the agricultural problems of the 48 States but during this period were extended into Alaska and the island possessions of the United States and thus reached from near the Arctic Circle to the tropical regions of Puerto Rico, Hawaii, and Guam.

With the growth of the State agricultural experiment stations there was developed a large and constantly increasing amount of cooperation between them and the different bureaus and offices of the Department. The use of large and increasing amounts of Federal funds by the State stations made their alliance with the Department increasingly close and permanent. There was thus a growing tendency toward a unified system of agricultural research in the United States, through the voluntary combination of the Federal and State agencies for agricultural advancement, based on the application of science to the practical affairs of farming and country life.

The vast number of experimental enterprises in which the Department engaged to a greater or less extent precludes making at this time anything like a complete summary of their purposes and results. Attention will be confined to a comparatively limited number of the more important undertakings, and particularly those which yielded substantial results. An effort will be made to cite examples that show as far as possible the nature and usefulness of the experimental work of the different branches of the Department.

The Weather Bureau, under Willis L. Moore, made studies of meteorological conditions in the upper air by means of kites and

captive and free balloons carrying a light form of meteorograph which recorded the pressure, temperature, humidity, and wind velocity. From 1909, daily flights were made. Most of the 1,772 flights made between 1907 and 1912 were in the level below 3 miles, but on September 1, 1910, a small free balloon reached a height of 19 miles above sea level. The Mount Weather observatory also made a series of measurements of the amount and intensity of solar radiation, the degree of absorption of the earth's atmosphere, and the polarization of blue skylight.

As the functions and work of the Department grew in variety and extent, its organization was expanded and strengthened by the organization of bureaus to replace, in large measure, the units called divisions, or to provide for the administrative combination of divisions whose work was in closely related fields. The movement in this direction was begun in 1900 by adding to the Weather Bureau and Bureau of Animal Industry, a Bureau of Plant Industry (*144*). This included the Divisions of Botany, Vegetable Physiology and Pathology, Agrostology, Pomology, Gardens and Grounds, and Seed Distribution. The Office of Fiber Investigations had been discontinued in 1898 and its work transferred to the Division of Botany.

In 1901, Bureaus of Chemistry, Soils, and Forestry took the place of divisions with the same names, and in 1905 when the management of the national forests was transferred from the Interior Department to the Department of Agriculture, the Bureau of Forestry became the Forest Service. In 1902 the Division of Statistics and the Division of Foreign Markets, which was created in 1898, were united in the Bureau of Statistics. The Division of Entomology in 1903 and the Division of Biological Survey in 1904 became bureaus. The Office of Roads Inquiry became the Office of Public Roads in 1904.

The Office of Experiment Stations, with its nutrition investigations, was expanded to include irrigation investigations in 1898, drainage investigations in 1902; and, as separate units, agricultural experiment stations in Alaska in 1898, Hawaii in 1901, Puerto Rico in 1901, and Guam in 1908.

A Solicitor was appointed in 1905 to have charge of the growing legal work of the Department.

The Museum was practically abolished in 1904, when the building in which it was housed was torn down to make room for the new departmental building.

The Bureau of Animal Industry, under D. E. Salmon until October 31, 1905, and thereafter under A. D. Melvin, who had been Assistant Chief since 1899, continued investigations on the tick carrier of cattle fever.

The later work relating to this disease has included the determination of the shortest and longest periods of time in the development, at all stages, in the life history of the Southern cattle tick, the carrier of Texas fever of cattle; the determination that apparently healthy southern cattle may continue to carry the parasite that causes Texas fever in their blood for years after they have been removed from the so-called infected territory and have been protected against all sources of infection, and the determination that noninfectious cattle ticks become infectious and capable of causing Texas fever by living a single generation on the bodies of southern cattle that have been kept half a dozen years or longer in apparently perfect health north of the Texas fever territory, and away from all sources of infection (*208, p. 167*).

Prolonged investigations showed the efficiency of arsenical dips as remedies for destroying cattle ticks, and the proper strengths of the dipping solutions were determined.

The transmissibility and the transformability of the human, bovine, and avian types of tubercle bacilli were made the subject of study; also the different methods of immunization; the retention of vitality by tubercle bacilli that chance to be lodged in cheese, butter, or eggs; and the occurrence of the different types of tubercle bacilli in cases of natural infection of birds and animals in captivity.

Other investigations on tuberculosis have thrown much light on the relation between the location of tuberculosis lesions in the animal body and the channels through which tubercle bacilli are expelled and disseminated from the bodies of tuberculous animals; on the persistence of the life and virulence of tubercle bacilli under different conditions and in different media; on the relation between tuberculosis of lower animals and human beings; on the relation between tuberculosis of cattle and tuberculosis among other species of animals; on the persistence of tubercle bacilli in a latent or semilatent state, without loss of virulence, in the tissues of living animals; on the causes that are responsible for the increased frequency of tuberculosis among hogs, etc. (*208, p. 168*).

The discovery that tubercle bacilli are of common occurrence in the feces of even apparently healthy tuberculous cattle explained the occurrence of tubercle bacilli in the milk of such cows, and made it possible to prove definitely that the feces of tuberculous cattle are a common cause of tuberculosis among hogs.

The investigations into the cause of hog cholera culminated in 1903 in the discovery that it is caused by a micro-organism of too minute size to permit its being defined through the most powerful microscope. This was followed by the production of a protective serum from immune hogs.

The diagnosis of glanders, Malta fever, dourine, and infectious abortion by the application of complement-fixation tests to the blood serum made it possible to recognize and identify these diseases accurately and promptly.

Important studies were made of so-called swamp fever of horses in the lowlands of the northern prairie States, forage poisoning of horses in Middle West and Atlantic States, and bighead and necrobacillosis of sheep and their poisoning on the western ranges from eating certain plants, such as the loco weed.

Much work was done on animal parasites and parasitic diseases. The life history of the stomach worm of sheep was worked out; the presence of the gid parasite of sheep and the common occurrence in their muscles of a tapeworm cyst, which is the intermediate stage of a dog tapeworm, were discovered; a common stomach worm of horses was found to be transmitted by the horsefly; and preliminary studies were begun which ultimately led to the discovery of the hookworm of man and its extensive distribution in the United States. Numerous new species of parasites were discovered, and an index of the extensive literature of parasitology was published.

Beginning with 1902 the Dairy Division of the Bureau of Animal Industry carried on laboratory work, largely in cooperation with the agricultural experiment stations in Wisconsin, Connecticut, and Missouri. The most notable results from this work were as follows:

The determination of the influence of the breed, the individuality of the animal, and the period of lactation on the composition of the milk; a study of the bacteria surviving pasteurization, and the discovery that certain types of lactic acid bacteria are sufficiently resistant to heat to withstand the tempera-

ture of pasteurization, showing that properly pasteurized milk will sour normally; the exact determination of the changes produced in milk by the heat of pasteurization, showing that certain objections to pasteurization are unfounded; the determination of the bacteria and fungi concerned in the ripening of Camembert cheese, and the establishment of methods of making this type of cheese in this country; the discovery that certain types of bacteria hitherto unobserved in Cheddar cheese attain large numbers during the ripening period, and are probably concerned in the production of the flavors; the development of a method whereby cheese of a uniform quality can be made from pasteurized milk; the establishment of the fact that the ordinary off flavors of butter are caused, not by microorganisms, but by spontaneous chemical changes, some of which are induced or accelerated by the acidity of the cream and the presence of iron or copper salts, and in which oxygen inclosed in the butter takes a part. As a result of this latter work it has been demonstrated that butter can be made which will retain its sweet flavor in storage for many months (*208, p. 159*).

Work in animal husbandry was definitely begun in 1901 but was materially expanded by specific appropriations from 1904. It included principally breeding and feeding experiments conducted in cooperation with agricultural experiment stations. The breeding work dealt with carriage horses in Colorado, perpetuation and improvement of the Morgan horse in Vermont, draft horses in Iowa, Holstein-Friesian cattle in South Dakota, Milking Shorthorn cattle in Minnesota, sheep in Wyoming and at the Bureau's farm at Beltsville, Md., and Barred Plymouth Rock fowls (with reference to the inherintance of egg production) in Maine. Feeding experiments in economic production of beef under southern conditions were made in Alabama. The respiration-calorimeter experiments with cattle, conducted at the Pennsylvania State College by H. P. Armsby, were reinforced for several years with funds from the Bureau of Animal Industry.

In 1901 the Department's work on plants was consolidated in the Bureau of Plant Industry. This led to great expansion of such work in many different lines. A large and constantly increasing amount of the activity of this Bureau was carried on in cooperation with the State agricultural experiment stations and private individuals, but the Bureau also maintained a considerable number of field stations. The Bureau was in charge of Beverly T. Galloway, who had been Chief of the Division of Plant Physiology and Pathology.

The plant-introduction work, inaugurated in 1898, developed into a system of world-wide agricultural exploration, through which over 34,000 plant varieties and species were brought into the United States. These were propagated at Washington or at outlying field stations, and as far as possible their progeny was distributed to experiment stations and private experimenters and plant breeders in the States and tropical possessions. A historical record of all these introductions and distributions was kept.

The Japanese varieties of short-kernel rice, brought in during 1898 and 1901, proved very important factors in the vast spread of rice growing in southern Louisiana and Texas, where the total output increased from less than 100,000,000 pounds in 1896 to over 687,000,000 pounds in 1911.

Drought-resistant durum wheat, brought in about the same time, became a great crop in the Northwest. Swedish Select oats were also extensively grown in this region. Turkestan, Siberian, Arabian, and Peruvian alfalfas helped to make the growing of this crop a success

in many localities. Hardy hybrid strains of alfalfa which grew in the Southwest throughout the winter were developed. Sudan grass, a kind of sorghum, attracted much attention in the southern portion of the Great Plains. Rhodes grass from Africa proved useful for hay in Florida and the Gulf coast region.

Seedless grapes from Italy and Greece proved useful in the table-grape and raisin industries of California. Date palms were successfully grown on a commercial scale in Arizona and California. Chinese wild-peach stock proved to be hardy in the Middle West. Groves of the superior-flavored oriental mango were planted in Florida, Porto Rico, and Hawaii. Guatemalan and Mexican avocados and selected seedlings of West Indian and Florida origin were successfully grown in Florida and California. Chinese varieties of persimmons proved as well suited to conditions in the United States as did the Japanese varieties.

At eight field stations in the West, six of which were operated in cooperation with the Reclamation Service, problems in the introduction of agriculture under irrigation were investigated by means of field experiments involving the growing of varieties of crops selected with reference to their suitability to local conditions and methods of cultivation.

In the vast semiarid region of the Great Plains from the Canadian border to the Gulf of Mexico, where there were many efforts to practice agriculture by a system of "dry farming" without irrigation, the Department carried on various kinds of botanical and agricultural investigations for many years prior to 1906, when the Office of Dry-Land Agriculture was organized. By that time it had become evident that a more comprehensive and permanent plan of investigation was needed and that it would be many years before the requirements of agriculture in many parts of this region of scanty rainfall would be determined.

By 1913, 18 field stations were in operation in 9 States. Of these, 8 were in cooperation with State experiment stations and 4 with other branches of the Bureau of Plant Industry. The investigations included crop rotations, cultivation and tillage methods, conservation of soil moisture, and meteorological observations.

Studies of the relation of alkali soils to plant growth made possible definite recommendations of crops best adapted to various types of alkali land. Laboratory experiments gave much information on the relative toxicity of the different alkali soils and the influence of alkali on the utilization of soil moisture by plants.

Field and laboratory investigations showed that the adaptability of plants to dry-land conditions depended, primarily, on their ability to manufacture a given quantity of dry matter with a minimum expenditure of water and that this principle could be utilized in breeding drought-resistant strains of various crops.

Studies of the native vegetation on different types of land in the Great Plains showed that the composition and character of the natural growth in any locality is a reliable indicator of the capabilities of the land for crop production.

In the South, efforts to breed varieties of cotton of better types, larger yields, and more resistance to disease resulted in securing numerous useful varieties, but also in showing the desirability of local adjustment of varieties.

The importance of community action to limit cotton culture in any particular region to a single variety was brought out. This led to efforts to establish national standards for American cotton, as a basis for marketing this crop.

The Bureau of Plant Industry, as well as many experiment stations, showed that by crossing and seed selection and by introduction of new varieties of corn to meet the requirements of local environment, increased yields of better quality could be brought about.

Investigations bearing on the grading, storage, and transportation of grain were begun in 1906. Special attention was given "to causes and degree of deterioration and actual shrinkage as influenced by moisture content, soundness, and climatic conditions" (*208, p. 134*). Work was done that led to the establishment of standard grades for corn and other grains on a scientific basis.

The old standard types of tobacco were improved by seed selection; new types were produced by breeding in the Connecticut Valley, in Maryland, and in Ohio; and desirable foreign varieties, including Sumatra and Cuban wrapper leaf and the filler grown from Cuban seed, were successfully introduced. The use of rotations and commercial fertilizers in tobacco culture was studied. The fundamental principles of curing and fermenting tobacco were thoroughly studied, and very successful applications of the results were made in the cigar-wrapper leaf and flue-cured districts. Progress was made in finding means of control of diseases, particularly tobacco root rot and those occurring during curing.

From the establishment of the Arlington Farm in 1901, investigations relating to vegetables were systematically developed. Work with potatoes was undertaken at field stations from Maine to California, and included introduction of varieties from abroad, testing for disease resistance, adaptation of varieties to local conditions, and determination of regions best suited for producing seed supply.

Investigations relating to peanuts, begun in 1905, greatly stimulated the spread of this crop in the South. The peanut industry was aided by the invention of machinery for digging and picking the nuts. A peanut-oil industry was being developed, the manufacture of peanut butter and confections was becoming important, and the use of peanuts as human and stock food was greatly extended.

The beet-sugar industry was greatly aided by the continued work of the Department, particularly in the determination of localities best adapted to the beet crop, the methods of culture best suited to growing this crop under irrigation, the causes and control of sugar-beet diseases, and the demonstration that seed of good quality could be produced in this country from strains bred here.

The identification, classification, and grouping of fruit varieties continued to be important lines of work. Investigations relating to the problems arising in connection with the handling, transportation, and storage of fruit proved useful in aiding the development of cooperative-marketing organizations among fruit growers.

Plants used in the production of drugs, oils, and perfumery were studied, and in some cases experiments in their cultivation in suitable localities were made. Experiments with tea plants were resumed, and a marketable crop was produced. Plants poisonous to stock on western ranges were studied.

In the development of the science of plant pathology, particularly with reference to cultivated plants and forest trees, the Bureau of Plant Industry maintained during this period the leadership which had been gained in the earlier work of the Division of Vegetable Pathology. In addition to determination of the causes and nature of many plant diseases, means for the partial or complete prevention or control of these diseases were worked out by laboratory and field experiments. Only a limited number of the investigations in which definite results were obtained can be mentioned in this general review of the work. In a review of the Department's work published in 1912 it was stated that—

The cause of the crown-gall of plants has been determined, and it has been discovered that this disease resembles animal cancer in its manner of growth and is due to bacteria lodged inside certain of the proliferating cells.

It has been proved that infection of Stewart's bacterial disease of sweet corn is produced by means of seed corn; that the black rot of crucifers, the brown rot of potatoes, the wilt of cucurbits, and other bacterial diseases are distributed by insects and slugs; that tobacco wilt is spread by nematodes; that bacterial infection can take place through stomata in the absence of wounds, as in the case of the black spot of plum, a disease of sweet corn and broomcorn, and other plant diseases; that acid canes are resistant to the bacterial disease of sugar cane; that many bacteria, including *Bacillus typhosus*, are readily destroyed by freezing; that the Granville tobacco wilt is identical with the bacterial brown rot of potato, eggplant, and tomato, and hence these plants should not be used in rotation.

The cause and remedy of the olive tubercle disease, coconut bud rot, bacterial mulberry blight, and a new knot disease of citrus trees have been discovered.

It has been shown that the cause of a large part of potato rot is due to *Bacillus phytophthorus*, and that the rot is arrested in tubers stored below 8° C. (*208, p. 136*).

Effective methods of controlling pear blight, apple bitter rot, and other apple diseases such as scab, leaf spot, powdery mildew, and blotch were found.

Little peach, a serious disease akin to peach yellows, was discovered and an eradication method of control was worked out. The self-boiled lime-sulphur solution was shown to be an effective remedy for the brown rot and scab of peaches without injuring the peach foliage.

Treatments for grape anthracnose and black rot were found. A number of serious fungus diseases of the cranberry were investigated and effective methods of control were devised.

The cause of a group of destructive wilt diseases of cotton, cowpea, watermelon, tomato, and other plants in the Southern States was found to be root- and stem-infecting fungi (*Fusarium* spp.), and a practicable method of control was developed through selection and the breeding of disease-resistant varieties.

Tobacco root rot, tomato wilt and rot, and the whole group of nematode diseases were studied and control measures were introduced. The copper-sulphate method for destroying objectionable algae in city water supplies without lowering the safety of the supply was discovered and practically demonstrated.

A general pathological survey of the national forests was made, and extensive experiments were inaugurated for controlling forest diseases by the improvement of forest hygiene. In work on diseases of forest-nursery stock it was found that the leaf blight of young conifers could be controlled by slight modifications of nursery practices, and damping-off of forest-tree seedlings could be remedied by

the use of soil fungicides, particularly sulphuric acid. Strenuous efforts were made, in cooperation with 11 States, to investigate and control chestnut blight.

Among the results of studies in plant physiology the following were reported:

> An accurate method for measuring the oxidase content of plant juices, which has particular application in determining physiological phenomena accompanying many types of plant diseases; increased knowledge of the physiological conditions affecting the keeping qualities of sweet potatoes in storage and a consequent avoidance of the heavy annual losses from their rapid deterioration; a better understanding of the inorganic food requirements of plants and of the influence on plant development of various ratios of these inorganic constituents; and additional light upon existing confusion as to the toxicity of certain molds occurring in spoiled foods and the harmlessness of others of the same group, as the result of a study of the metabolism of molds and of the conditions under which they elaborate toxic products (*208, p. 140*).

The Forest Service, under Gifford Pinchot from 1898 to 1910, and later under Henry S. Graves, conducted scientific and practical experiments which added to fundamental knowledge about forest management and the utilization of forest products. Silvicultural and other studies were carried on to obtain information applicable to the best management of woodlands in all parts of the country. Dendrological investigations were made which included studies of the distinguishing structural characteristics of important native trees and of foreign woods for which inferior substitutes might be placed upon the American market.

Experimental reforestation was studied; the best silvicultural systems and degrees of cutting to secure natural reproduction; the effect of forest cover on stream flow, excessive wind movement, and evaporation; the deterioration of fire-killed timber; the damage caused by light surface fires; and the growth, yield, utilization, and life history of a number of important western trees were investigated.

Studies of forest products, mainly at the Forest Products Laboratory at Madison, Wis., yielded important results on the preservative treatment of fence posts, railroad ties, and telegraph and telephone poles, use of previously neglected kinds of wood for paper making, increasing the yield and quality of crude turpentine, manufacture of wood distillation products, kiln drying of lumber, and physical properties of woods and timbers with reference to adaptability to different purposes. Tests of the woods and of their products led to large economies in consumption and to the utilization of various species formerly disregarded.

The Forest Service, in cooperation with the Bureau of Plant Industry, in 1907 undertook investigations on the systematic and wise use of the vast area of range forage within the national forests. Fundamental principles of managing range and livestock were developed and were rapidly put into application, with marked improvement in the use of the national-forest areas for livestock grazing without endangering usefulness for the production of timber, protection of watersheds, and for game and recreation.

The Bureau of Soils, under Milton Whitney, made largely fundamental physical and chemical soil studies, which showed more fully the complex character of soils and the many factors determining their proper agricultural use. Much emphasis was laid on the importance

of the physical condition of the soil and the composition of the soil solution in their relation to tillage, fertilizers, and to crops and their rotations on particular soils.

Important conclusions regarding the enduring and regenerative power of soil were reached—

> through a mineralogical study of soils and rocks, the study of the solubility of soil minerals and of the composition of the soil solution, the study of the profound changes taking place in the soil constantly through the mixing of soil grains by erosion, winds, and internal movements, and in the soil constituents through the action of percolating and capillary waters, the study of the increasing yield of farm crops during the 40 years for which records have been kept in this country, a study of the much larger increases in yields on the older soils of Europe during the past 300 years, and by a comparison of the chemical composition of the relatively new soils of this country and the relatively older agricultural soils of Europe (*208, p. 151*).
>
> The soil is not static, as was formerly supposed, but is dynamic, with many functions continually at work producing changes and always mutually affecting one another, and these changes can also be profoundly influenced by the substances ordinarily used as soil amendments (*208, p. 153*).

The Bureau worked out a scheme of classifying soils with reference to their origin and constitution. This scheme was used as the basis of the soil survey (p. 226) and was modified as the survey and related studies progressed. The special adaptation to crops of many of these soil types was worked out as the survey proceeded. Through laboratory research it was also discovered that crops differ in their effect on soils, that they thus influence succeeding crops, and that for the highest development of the soil there must be a certain general order of rotation, determined by the nature of the soil and the crops as well as by climatic conditions and cultural treatment. Commercial fertilizers were shown to have very important functions in addition to that of supplying mineral plant foods.

The Bureau of Chemistry, under Harvey W. Wiley, not only performed a large amount of chemical work for other bureaus in the Department of Agriculture and other Federal departments but also conducted much research of its own. Studies of methods of analysis were continued in cooperation with the Association of Official Agricultural Chemists.

In 1903 a study of methods of making better table sirup was begun. A model factory was erected at Waycross, Ga., where manufacturing problems were investigated, and many economies, not only in the processes of manufacture of sirup but in utilization of the bagasse for fuel to drive the mill, press the cane, and evaporate the juices, were worked out.

Important studies were made on the effect of smelter fumes on farm crops, forests, and farm animals, and in the manufacture of sulphuric acid by condensing the fumes.

An exhaustive study of feeding stuffs on the market was completed in 1908 and the feeding value of various cereals was investigated.

Investigation of the processes of tanning and paper making suggested important improvements in these processes. Studies of the distillation of turpentine showed that dead trees, sawdust, stumps, and other refuse of the lumber industry could be used for making turpentine, resins, and various chemicals. Through the operation of a model distillery, valuable data on the yield of alcohol from various farm products were secured.

Many studies of manufacturing processes and trade practices were made in connection with work under the Food and Drugs Act. The effect of cold storage on various food products was extensively investigated. Chemical and bacteriological examinations of oysters before and after shipping and of the pollution of oyster beds from sewage, led to correction of bad commercial practices. Studies by this Bureau aided manufacturers and dealers in making their goods conform to proper standards. For example, an investigation of methods of preparing and shipping poultry and eggs in such a manner as to prevent deterioration produced results which reduced losses and improved the quality of the product. The Bureau also studied the materials used in making cans, and the best temperatures and lengths of time for processing.

The Bureau of Entomology, under L. O. Howard, greatly expanded its original research in the field of economic entomology. The complete life histories of many hundreds of species of injurious insects were worked out, the parasitology of insects was studied in a large way, apparatus and insecticides were developed or improved, and other measures were discovered or devised for the prevention or diminution of insect ravages on agricultural crops in the field or the greenhouse, or on the harvested and stored products. Useful work in apiculture was also done. The Bureau cooperated with the State experiment stations and other organizations and was able to put at their disposal or to use for their benefit a great fund of new knowledge. Whereas in 1897 the work was carried on almost entirely in a single laboratory at Washington, by 1913 the Bureau had 35 field laboratories in different parts of the United States, nearly all of which were well equipped for research on particular insects or groups of insects.

Among the investigations which yielded important practical results were those on the San Jose scale and its control; on the Mexican boll weevil, which furnished a basis for a system of cotton-plantation management, enabling the planter to grow good crops even in the presence of the weevil; and on parasites and natural enemies of the gypsy and brown-tail moths in New England, black scale of the orange and olive, the elm leaf beetle, and the alfalfa weevil.

Many European parasites were imported and in return American parasites were sent to foreign countries, as for example a minute parasite of the mulberry scale was sent to Italy and in its new environment proved a very destructive enemy of the scale.

The process of fumigating citrus trees with hydrocyanic acid gas was made very much cheaper as a result of the Bureau's work. Investigation of seven species of bark beetle of the genus *Dendroctonus*, which had killed immense amounts of merchantable pine, spruce, and Douglas fir timber, gave very complete knowledge of these insects and led to methods for their control.

Studies of insect carriers of diseases of man and animals yielded much useful information on the mosquitoes which carry malaria and yellow fever, the housefly which spreads typhoid fever and other intestinal diseases, and the ticks which carry the Rocky Mountain spotted fever and tick fever of cattle.

The Bureau of Biological Survey (under C. Hart Merriam, succeeded by H. W. Henshaw in 1910) continued and expanded its

investigation of the geographic distribution of mammals and birds and its preparation of maps showing the natural life zones of the country. The ranges, abundance, and habits of many of the North American mammals and birds were determined. Detailed studies were made of certain regions, notably Mount Shasta, Calif., and the States of Colorado and Arkansas. The first complete list of the birds of Arkansas was published. Careful studies of the food habits of many injurious and beneficial birds were made. The food habits of birds in the fruit-growing districts of California and of some generally distributed groups, such as flycatchers, grosbeaks, shore birds, and waterfowl, were especially studied. Methods were devised for destroying English sparrows, wolves, coyotes, moles, rats, ground squirrels, and prairie dogs. Problems in the permanent preservation of buffalo, elk, antelope, and other big game and of numerous species of birds were studied.

The Bureau of Statistics (under John Hyde, succeeded in 1905 by Victor H. Olmsted) made a number of statistical studies in the field of rural economics. These studies covered such things as land tenures, transportation, the production and use of important agricultural commodities in foreign countries, the history of agricultural production in the United States, the costs and methods of marketing agricultural products, and the organization and work of cooperative farmers' associations in production, buying, selling, insurance, and warehousing.

The Office of Public Roads (under Roy Stone to 1900, followed by Martin Dodge to 1905 and Logan W. Page to 1912) aided in improving methods of testing the physical properties of rock for road building; investigated the properties of oil-mixed Portland-cement concrete; made valuable measurements of the expansion and contraction of concrete while hardening; conducted experiments to determine the efficiency of oils, tars, asphalt, and other preparations used to prevent dust and to preserve macadam roads; studied the decomposition of rock powders under the action of water; and investigated the corrosion of iron and steel culverts and fences and protective coatings for these structures.

The Office of Experiment Stations, under A. C. True, continued and expanded its studies of agricultural education at home and abroad, partly in cooperation with the Association of American Agricultural Colleges and Experiment Stations; and further developed the investigations on human nutrition, largely carried on in cooperation with agricultural colleges, experiment stations, and other institutions in different parts of the country.

The respiration calorimeter was perfected and used in elaborate experiments with human subjects to determine the utilization of different foods and rations by the body and the amounts of energy expended in different kinds of work as related to the diet. A small respiration calorimeter was constructed for the study of fruit ripening and other problems in vegetable physiology.

Digestion experiments with bread made from different kinds of flour, and of other foods were carried on.

The effects of cooking processes on the nutritive value and digestibility of various foods and on the relative value of different food-preparation methods, as judged by quality, palatability, and the labor involved, were investigated.

Numerous dietary studies carried on in homes and public institutions furnished valuable data on the food habits of American people and helped in formulating dietary standards for home and institution management.

The irrigation investigations begun in 1898 included extensive studies of the irrigation laws of the United States and other countries and the legal principles on which such laws should be based, problems of water rights and their administration, the duty of water, methods and cost of pumping and storing water, prevention of losses and wastes in distribution and application of water to crops, and amounts of water required by different crops and methods of culture.

The drainage investigations grew out of the need for drainage systems as supplements to irrigation, but they were extended to studies of drainage problems in the humid regions. Drainage requirements in various localities and under differing conditions were studied and a large amount of useful technical data on various phases of the subject was collected.

The work of the Alaska Experiment Stations, begun at Sitka in 1898 and afterwards extended to Kenai, Copper Center, Rampart, Fairbanks, and Kodiak, had for its general purpose the determination of the agricultural possibilities and self-sustaining capacity of this Territory as far as they could be determined by systematic experiments in a few localities of this vast region with its great diversities of climate, rainfall, soils, and native growths, and from information given by settlers in various parts of the Territory. The work was necessarily of pioneer character and consisted chiefly of clearing and preparing land for the cultivation of crops, introducing and testing varieties of plants, selecting and crossing of varieties, and attempting to maintain cattle and sheep as largely as possible on native forage, either green, dry, or stored as silage.

At Sitka, where the headquarters of the whole enterprise was established, horticulture was given prominence, and experiments were made with many kinds of garden vegetables, bush fruits, apples, and cherries. Hybrid strawberries grown there excelled in hardiness and quality the other cultivated varieties tested. Other hybrid fruits were produced. Hardy varieties of grain, alfalfa, clover, potatoes and other vegetables, and flowers, some of which came from Canada, Siberia, or northern Europe, were widely distributed and grown successfully.

Experimental work was undertaken at Kenai and Copper Center but abandoned after a few years.

At Rampart, within about 5° of the Arctic Circle, experiments with hardy spring varieties of wheat, rice, oats, and barley showed that these crops would regularly mature there and that even winter wheat and rye could be grown, whenever the ground was deeply covered with snow, in the coldest weather. Attention was therefore turned with much success to the breeding of varieties especially adapted to that region.

It was thought that the building of a railroad to Fairbanks would lead a considerable number of settlers to gradually take up homesteads in the large region of comparatively good agricultural land along this line near Fairbanks. A station was therefore opened near

that place, at which experiments on fields of considerable size were undertaken. Cereals, grasses, and potatoes grew well there.

The general results of the work with plants in Alaska during this period showed that, properly cultivated, suitable varieties of cereals, grasses, potatoes, and a considerable number of different fruits, vegetables, and flowers could be successfully grown in many localities south of the Arctic Circle. Some progress was also made in developing cattle and sheep production in the Territory.

The Federal experiment station at Honolulu, Hawaii, was established in 1901 and was intended to supplement the work of the private Sugar Planters' Station, which was dealing with the sugarcane industry predominant in this Territory. Diversification of agriculture was therefore the main problem of the Federal station.

Studies of Hawaiian soils showed certain peculiarities affecting plant growth and the use of fertilizers. Important insect pests were studied and methods for controlling some of them were discovered. Introduction of new varieties of plants and the breeding of varieties better adapted to Hawaiian conditions were important lines of work. The pineapple industry, in its infancy when the station was established, was greatly helped by the station and became of second importance among the agricultural industries of the island.

The station's work on soils, varieties, and experimental shipping of the fruit to the mainland was a large factor in the success of the industry. The injurious (chlorotic) effect of manganiferous soils on pineapples was shown, and a corrective (spraying with a solution of iron sulphate) was found. The possibility of tobacco growing in Hawaii, if economic conditions were favorable, was shown in the early work of the station. Sea-island and Caravonica cotton were successfully grown as perennial crops.

Japanese varieties of rice were introduced, and new varieties giving better yields were bred. The superiority of sulphate of ammonia to nitrate of soda as a fertilizer for rice was shown. Somewhat similar work was done with taro. Successful experiments were made in tapping Ceara rubber trees, collecting the rubber, and preparing it for market. Practical methods of propagating choice varieties of tropical fruits, such as mangoes and avocados, were worked out.

The Puerto Rico Experiment Station, established near San Juan in 1901 and later removed to Mayaguez, promoted the diversification of agriculture. Much attention was given to citrus-fruit and pineapple production. The station demonstrated the value of windbreaks in culture of citrus fruits, and showed that strongly calcareous soils induce chlorosis of pineapple, rice, and other plants.

The value of pruning, fertilizing, and cultivating as means of renovating coffee plantations was demonstrated. Varieties of many higher priced coffees were introduced. The causes of several diseases of coffee plants were determined and the life history and habits of insect pests of these and other plants were investigated. Experiments were made with introduced forage plants, especially those which were drought resistant. Improved breeds of horses, cattle, swine, and poultry were introduced, and experiments in cross-breeding were made.

The Guam Experiment Station, established in 1908, undertook to rehabilitate the agriculture of the island in order that it might meet

more fully the food requirements of the population. Special attention was given to experiments with corn, and many tropical varieties were introduced. Para grass was shown to be especially well adapted to the island. A number of leguminous plants and different kinds of vegetables were grown successfully. It having been proved that feeds could readily be produced, Morgan horses, Ayrshire cattle, Berkshire hogs, and Barred Plymouth Rock and Brown Leghorn chickens were introduced.

AGRICULTURAL EXPERIMENT STATIONS, 1906–13

Work under the Adams Act (*4*, *188*), passed in 1906, immediately increased interest in the more scientific work of the stations. Members of the staffs were, in general, so desirous of having projects which would be approved under the Adams Act that a much larger number of projects were proposed than could be financed with the Adams fund in the year 1906–7. After careful scrutiny 320 projects were approved. The number ranged from 2 to 13 in the several States. This was far too many to be adequately prosecuted with the funds then available under the Adams Act. The result was that many projects were supported only in small part from the Adams fund, and in some cases lines of work classed under that fund were actually supported entirely from other funds.

The scope and character of the investigations to which the Adams funds contributed were shown by summary accounts of them published in the annual reports of the Office of Experiment Stations from 1906 to 1914, from which the following statements have been compiled.

The plant-breeding projects included studies upon heredity in plants, the variability in morphological characters in cultivated wheat, the extent of hybridizing in nature and the environmental conditions associated therewith, effects of external environmental factors upon hereditable morphological characters, and the correlation of visible morphological characters with the presence and distribution of such constituents as gliadin, glutenin, and starch in the grain. Corn breeding for the semiarid region was taken up with the factors which constitute drought resistance as its basis, and the development of immune, disease-resistant strains of crops was taken up on the basis of studies of what constitutes immunity in different cases and of the principles underlying development of disease resistance.

Investigations into the pathology and physiology of plant diseases included such matters as the relation between the character of the soil and certain diseases—notably the relation of marly soils and of lime to chlorosis of citrus fruits, the specific influence of the different factors which make up climate upon the health of plants and their susceptibility to disease, and the relation of nutrition to susceptibility.

Systematic studies of a large number of plant diseases were made. In some cases these were new or little-understood diseases; in others the object was to clear up doubtful points about the life cycle, relationships, susceptibility to various influences, and means of dissemination of the organisms inducing the diseases as a more intelligent basis for combating them.

In entomology there was a large and varied list of projects. In a number of cases it was found desirable to go back to some of the most common insect pests and study more thoroughly certain points in their habits and life histories, environmental conditions which affect them, and similar matters, as bearing ultimately on methods of control. Several investigations dealt with the toxicity of various insecticides, the manner in which they act, and similar points, as well as with their physiological effects on the trees and plants receiving the treatment.

In horticulture, physiological studies included such things as the causes and means of control of fruit-bud formation on the apple and peach; the physiology and philosophy of pruning and of grafting, both involving extensive systematic studies; the elimination of the color of peach twigs by breeding to make them less susceptible to early frost; the factors affecting the setting of fruit on the tomato to determine the cause of failure to set in dry localities where the plants bloom freely; and other studies of the effect of environmental conditions.

Projects in dry farming included special investigations on the absolute water requirements of plants, the periodicity of this requirement, the water-holding capacity of the soil and factors which affect it, the conservation of soil moisture, and the breeding of drought-resistant crops.

In soil science there were studies of the fertilizer requirements of soils, the composition of certain plants as indicative of these requirements, the nature and extent of the influence exerted upon crops by the previous growth of other kinds of plants, the relation between soil conditions and the quality of crops (e. g., the staple of cotton), the effect upon the organic and inorganic constituents of plants of sodium salts applied to the soil, the roles of phosphorus and of potassium in plant nutrition, and the role of lime in the soil. There were also several projects dealing with humus, its nature and determination, relations to soil fertility, rate of formation under different conditions, behavior and conservation in the soil, and with the effect of various factors on the humus content.

Studies in soil bacteriology dealt with humus formation and change; relation of microscopic life of the soil to fertility in general; nitrifying and other biological properties of the soil; determination of the number, character, and biochemic functions of bacteria within the zone of tillage, to ascertain the part these organisms play singly and collectively in setting free plant food; and the bacteriological conditions in irrigated and unirrigated soil in the arid region, with special reference to the formation of nitrates and to the decomposition of barnyard manure.

Among chemical investigations on plants and their products were those of the nature and amount of nonsugars in sugarcane, and the conditions which affect their formation, with special reference to sugar manufacture; the gluten content of wheat, cause of its deterioration, and methods of correcting; the milling qualities of wheat as related to gluten and other factors; the factors affecting the lupulin, volatile oils, and other active principles of hops; an investigation of the various sugars and coloring matters in cacti; and the rationale of the ripening of the date.

Animal-nutrition studies were made on the behavior of the constituents of the nitrogen-free extract in digestion and their relation to nutrition; the influence of certain feeding stuffs in depressing the digestibility of rations, and the nature and cause of this effect; the process of digestion as influenced by certain factors; and the effect of treatment or preparation of the feed on the digestibility of its constituents. Some of the fundamental studies in animal nutrition concerned the influence of age and individuality on metabolism in cattle; the use which animals actually make of their food at different periods of growth, considered from a physiological standpoint; the role of phosphates in animal nutrition; the effects and importance of various other mineral constituents; and the specific effect of certain foods on the product, such as the hardness or solidity of pork and the character of the fat in butter.

Dairying projects dealt with the less understood properties of milk and their relation to differences in its nutritive value and the manner in which it agrees with consumers. Investigations were made upon bacteria, other than disease germs, in milk, which are detrimental to digestion; the leucocytes in milk under normal and abnormal conditions and their sanitary significance; and the constituents of cheese and their changes under the influence of certain classes of bacteria. Bacteriological and chemical investigations on the disposal of creamery sewage were also made.

Under animal breeding there were investigations in heredity; the effects of inbreeding; the breeding of animals under normal and abnormal conditions; effect of certain feeds, like cottonseed meal, upon prepotency; and the problem of artificial impregnation.

In poultry husbandry there were studies of incubation of eggs under the hen; the optimum conditions for artificial incubation in dry climates; conditions determining the egg-laying capacity of fowls and the fertility of eggs; and the cause of decay in eggs.

In veterinary science there were investigations relating to specific diseases; the immunizing of animals, with a study of the causes of natural immunity; stable ventilation in relation to the requirements of health; and the active principles of plants poisonous to stock. Several quite elaborate studies of the life history of the cattle tick as related to tick fever eradication were made.

USE OF THE HATCH FUND

During this period the use of the Hatch fund was considerably modified. Believing that the time was coming for the stations to discontinue much of the extension work which they had been doing, the Office of Experiment Stations insisted that as far as possible the Hatch fund should be used to pay the expenses of actual experiments. A definite ruling was made against the use of that fund for printing and distributing compilations and popular bulletins unless they recorded experimental work. Use of the Hatch fund on Adams fund projects was encouraged and increasing amounts were so used. Substantial increases in State funds for the stations in many States made it possible to utilize the Hatch fund more fully for definite experimental work.

SUBSTATIONS

The need of investigations and experiments in different parts of the States became increasingly evident, and many State legislatures responded liberally when interested people appealed for funds for such work. In 1913–14 about 70 substations were in operation in 23 States, and there were also local experiments and so-called demonstration farms in many places. This outside work was, in general, better organized than previously and had greatly increased financial support, so that it included many valuable experiments and often showed quite definitely to what extent the results of the work at the stations could be locally applied with advantage to the farmers.

EXTENSION WORK

Meanwhile the farmers' institutes and other extension work in which the agricultural colleges were engaged, grew apace. The necessity of more definite organization at the colleges for their extension work became increasingly apparent. Extension departments were formed in most of the colleges before the end of this period. Legislatures in many States willingly gave funds for extension enterprises. But the demand for extension work grew faster than the organization and means for its performance. The result was that in spite of increased extension funds, and in many States the employment of separate workers for the extension service, the experiment stations were increasingly burdened with extension work. In a number of States the station director was also the extension director. The number of station officers engaged in farmers' institute work increased from 389 in 1906 to 590 in 1914. Station workers were called upon to prepare many publications for use in extension work and were often taken away from their researches to attend extension meetings or to perform other service as extension specialists.

REGULATORY WORK

In the relations of the stations to regulatory work, there were two different tendencies during this period. In some States there was a marked increase in the extent and variety of this service performed by the station; in others the station was wholly relieved of much regulatory work, either by the transfer of this work to a State department of agriculture or by making it a separate department in the land-grant college. In 1906, fees for such work to the amount of $100,186 were reported by 19 stations; in 1914, stations in 14 States reported $234,794 from this source.

PUBLICATION OF RESULTS

The publications of the stations greatly increased in number and variety during this period. For the fiscal year 1906 the aggregate number was 463, and for 1914 it was 1,330. The annual report, which originally had been the repository of detailed accounts of the station's work, so declined in importance that in 1912 the Office of Experiment Stations felt obliged to call attention to the neglect in carrying out the provision in the Hatch Act which required each station to make annually "a full and detailed report of its operations." It appeared that a number of stations were failing to issue annual reports, and

in other cases the report had "degenerated into the briefest possible mention of the lines of work and the summarized expenditures, which furnish little real information and can have but little interest" (*8*).

The regular series of station bulletins became in many cases a confusing mixture of technical and popular publications, or the scientific material was so incorporated in the bulletins sent to the farmer as to bewilder and discourage him. At a number of stations separate series of technical and popular bulletins were published. Detailed accounts of the progress of the work under the Adams Act were often published in a wide range of scientific journals. This brought the scientific work of the stations more generally to the attention of the scientific world, but it often left the files of the individual station without any published account of important pieces of work, and made it almost impossible for the Experiment Station Record to obtain complete references to the station's work.

As early as 1907 the Director of the Office of Experiment Stations had called attention in his annual report to the need of special provision for the publication of the Adams fund work.

> Either the individual stations must establish with the aid of State funds a technical series of publications, which, though limited in editions, will be relatively elaborate and expensive, or Congress must make provision for the grouping together of the scientific work of the stations in a general series of special publications to be issued under the authority of the National Government.
>
> To the world at large the latter course would undoubtedly be the most satisfactory, since this would bring the research work of the stations together and establish a regular and permanent medium for its publication, thus making it readily accessible to scientists and students the world over. Foreign critics of our experiment station system have often said that under present conditions the National character of our system of agricultural research was obscured and the scientific value of much of the work of our stations was lost sight of because of the miscellaneous character of the station publications, and the multiplicity of the sources from which they emanated. There is little doubt that our stations would have a much better standing in the scientific world if their more scientific publications were differentiated from their popular ones and issued through a single regular channel. It is possible that an editorial board might be established through the Association of American Agricultural Colleges and Experiment Stations to represent the interests of the stations in this matter and that this board might act in cooperation with this Office in the preparation for the press of reports submitted by the individual stations (*172*).

A similar need for a serial in which some of the scientific work of the United States Department of Agriculture might be published led to the establishment of the Journal of Agricultural Research, the first number of which was issued in October 1913. At the meeting of the Association of American Agricultural Colleges and Experiment Stations at Washington in November 1913, B. T. Galloway, Assistant Secretary of Agriculture, read a paper (*71*) in which he suggested the appointment of a joint committee on the publication of research to pass on the papers submitted for publication in this journal. On the recommendation of the executive committee the association appointed three members to serve on such a committee. In a memorandum signed by the executive committee and representatives of the Department and approved by Secretary Houston, it was agreed—

> that in order to make available to students of science the research work of the department and stations and to promote its standing in the scientific world there should be published by the department a journal of agricultural research, such journal to contain only those contributions from the department and stations as are viséed by the committee selected for that purpose.

PERSONNEL AND FUNDS

The number of persons engaged in the administrative and research work of the stations increased from 950 in 1906 to 1,852 in 1914. Table 5 shows the increase of their funds during this period and the relative value of additions to their equipment in 1906 and 1914.

TABLE 5.—*Value of income and additions to equipment of the State agricultural experiment stations in 1906 and 1914*

Item	1906	1914	Item	1906	1914
Income from—			Additions to equipment:		
Hatch fund	$720,000	[1] $712,649	Buildings	$169,875	$609,200
Adams fund	240,000	[1] 713,518	Library	22,080	28,622
State funds	709,902	2,574,605	Apparatus	57,440	83,447
Individuals and communities	8,304	19,749	Farm implements	22,706	76,170
Fees	100,187	234,794	Livestock	51,978	131,915
Farm products	135,527	307,615	Miscellaneous	22,813	83,016
Miscellaneous	103,572	491,757	Total	346,892	1,012,370
Total	2,017,492	5,054,687			

[1] This was the amount actually expended from appropriations aggregating $720,000 under each act.

The station work throughout this period was confined almost entirely to problems of agricultural production. A department of rural economics was established in Experiment Station Record in 1905, but up to 1914 the abstracts included in this department were mostly from foreign publications or those of the United States Department of Agriculture. A few American stations, however, had made limited economic surveys, or studies of costs of production.

DEVELOPMENT OF RESEARCH IN AGRICULTURAL ECONOMICS AND SOCIOLOGY, 1913–21

UNITED STATES DEPARTMENT OF AGRICULTURE

ADMINISTRATIONS OF SECRETARIES DAVID FRANKLIN HOUSTON AND EDWIN THOMAS MEREDITH, 1913–21

David Franklin Houston was Secretary of Agriculture in the Cabinet of President Wilson from March 6, 1913, through February 1, 1920, and thereafter Secretary of the Treasury until March 4, 1921. He was born at Monroe, Union County, N. C., February 17, 1866; graduated at South Carolina College in 1887, and received the A. M. degree in 1892 at Harvard University, where he studied political science from 1891 to 1894. He was superintendent of schools at Spartanburg, S. C., from 1888 to 1891; adjunct professor, associate professor, and professor of political science at the University of Texas from 1894 to 1902; president of the Agricultural and Mechanical College of Texas from 1902 to 1905; president of the University of Texas from 1905 to 1908; and chancellor of Washington University, St. Louis, Mo., from 1908 to 1916.

While Secretary of Agriculture he was a member of the Council of National Defense from 1916 to 1920 and chairman of the Federal Board for Vocational Education from 1917 to 1920. While Secretary of the Treasury he was also chairman of the Federal Reserve and Farm Loan Boards.

Edwin Thomas Meredith (*277*) (Dec. 23, 1876–June 17, 1928) was Secretary of Agriculture from February 2, 1920, to March 4, 1921. He was born at Avoca, Iowa, and studied at Highland Park College, Des Moines, Iowa, 1893–94. He became publisher of the Farmers' Tribune in 1896, and from 1902 he was publisher of Successful Farming, in Des Moines. During his short term as Secretary of Agriculture he continued the policies of Secretary Houston and did much to bring the work of the Department to the attention of the business world. He also strongly favored a higher scale of salaries for the scientific and technical workers in the Department, believing that only in this way could competent and ambitious persons be secured and held in the Government service.

Beverly Thomas Galloway (p. 63) was Assistant Secretary of Agriculture from March 17, 1913, to July 31, 1914, when he became dean of the New York State College of Agriculture at Cornell University, returning in 1916 to the Department of Agriculture as pathologist in the Bureau of Plant Industry.

Carl Schurz Vrooman was Assistant Secretary of Agriculture from August 17, 1914, to December 31, 1918.

Clarence Ousley was Assistant Secretary of Agriculture at first under the Food Production Act, and later in the regular service, from August 21, 1917, to July 31, 1919.

James R. Riggs was Assistant Secretary of Agriculture from September 22, 1919, to March 31, 1920.

Elmer Darwin Ball was Assistant Secretary of Agriculture from June 12, 1920, to March 4, 1921, and Director of Scientific Work in the United States Department of Agriculture, 1921–25.

Raymond Allen Pearson was Assistant Secretary of Agriculture under the Food Production Act from August 21, 1917, to August 22, 1918, and George Irving Christie from October 14, 1918, to June 30, 1919.

CONDITIONS AFFECTING THE WORK OF THE DEPARTMENT

When D. F. Houston became Secretary of Agriculture in 1913 important economic and social problems relating to agriculture and country life were coming to the front. It was very fortunate for the Department of Agriculture that the man coming to its head at this time was well trained in economics and was thoroughly interested in the development of work in this direction. As he pointed out in an address before the Association of American Agricultural Colleges and Experiment Stations in November 1913, a large share of his time was given to "the consideration of problems such as tenancy, rural credits, marketing, cooperation, sanitation, and rural organization" (*101*).

Earlier in that year a large commission of farmers and other interested persons had visited the principal countries of Europe, under authority of Congress and with the cooperation of the Southern Commercial Congress, to study what was going on there in attempts to solve the economic problems of agriculture. Various phases of these problems were attracting attention in different parts of the United States. In the South the spread of the boll weevil and the severe fluctuations in the price of cotton were causing much alarm. The development of fruit growing and truck crops in many parts

of this region was creating difficult situations regarding the transportation and marketing of such products. In the Northeastern States a great increase of dairy husbandry was bringing about the formation of cooperative organizations to market dairy products. In the North Central States the rising value of farm lands, the growth of tenancy, and the unsatisfactory prices of grain and other staple crops were causing much agitation. In the Great Plains and farther West the rapid development of farming and fruit growing under irrigation was making the satisfactory marketing of the crops very difficult and perplexing. Widespread attempts at dry farming in the semiarid regions were creating the economic problems of speculative farming where scanty rainfall made crops uncertain. Moreover, in a general way, the changing standards of farm life that were being brought about by the automobile, the telephone, and rural free delivery of mail, were causing dissatisfaction with farm incomes and rural social conditions, and there was a large drift of young people from the farms to the cities.

Endeavors to remedy economic and social evils through the formation of cooperative organizations, and especially through the newly created farm bureaus, had only begun in promising ways when the World War and the tremendous upheaval which brought the United States into that struggle produced very unusual economic conditions. The demands of the Allies and then of our own Government for food, fibers, and other agricultural products needed for the vast numbers of men withdrawn from productive industries to engage in warfare caused a tremendous expansion of agricultural production in this country, in which more or less expensive machinery took the place of much human labor on our farms. High prices of farm products brought immense amounts of money into our rural communities. These funds were spent for improved farm and home equipment, automobiles, good roads, better schoolhouses, purchase of farms at unreasonably high prices, and speculative investments of many kinds.

The sudden and unexpected ending of the war and the first deceptive appearances of post-war adjustments led our farmers, including the thousands of soldiers returning to the farms, to continue production in abnormal amounts and found them unprepared to meet the radical and sudden change in economic conditions which occurred in the fall of 1920. The prices of farm products harvested at that time were 33 percent below those at planting time in that year. The selling value of farm lands also had a sharp decline. Farm assets, as represented by products and lands, shrank to the extent of many billions of dollars. On the other hand, the prices of the things the farmers had to buy were well maintained, and this made the financial condition of the farming people still more difficult and unsatisfactory.

In this strange and difficult period the farming people more than ever before looked to the United States Department of Agriculture and the agricultural colleges and experiment stations for advice and information which might help them to bear their unusual burdens and to solve their new problems. In the war time the Government and the people generally found in this Department a great and effective agency for aid in maintaining the quality and the quantity of supplies of foods, clothing, and other useful materials. The work of the Department was therefore greatly expanded, especially in regula-

tory, service, and extension work. Research on economic and social problems was added to that on agricultural production, but its amount and to a certain extent its character were somewhat severely limited in comparison with the other enterprises.

To make clear the situation in the Department with reference to experimentation and research between 1913 and 1921 it will be necessary to present first a brief summary of matters pertaining to its funds, personnel, change in organization, legislation affecting its activities, its regulatory, service, and extension work, and its dissemination of information.

The appropriations for the regular work of the Department rose from $17,986,945 for the fiscal year 1914 to $34,781,884 for 1921. Funds for other purposes administered by the Department amounted to $6,100,000 in 1914 and $269,513,180 in 1921. Of this latter amount $259,703,180 was available under the Federal Aid Road Acts, and $62,535,342 was expended during the fiscal year 1921. Other items were $5,080,000 for extension work under the Smith-Lever Act and $1,440,000 for agricultural experiment stations under the Hatch and Adams Acts. Of the $32,000,000 actually spent for the regular work of the Department in 1921, it was estimated that $9,000,000 was used for research, $3,000,000 for extension work, $3,000,000 for service work, and $17,000,000 for regulatory work. This indicates that there was little increase in the amount annually spent for research during this period. Under the Food Production Act for the stimulation of agricultural production and the conservation of food, the Department had special appropriations of $11,346,400 in the fiscal year 1918 and $11,031,863 in 1919.

On June 30, 1913, there were on the rolls of the Department 2,924 persons in Washington and 11,554 outside. Of the scientific and technical workers 1,812 were engaged in research, 1,323 in extension work, and 6,021 in regulatory and related work. During the war the number of employees was greatly increased, but after its close declined rather rapidly. The number of employees on June 30, 1921, was 18,748, a decrease of 628 from the previous year.

The following changes of bureau chiefs occurred during this period: In the Bureau of Animal Industry Alonzo D. Melvin died December 7, 1917, and was succeeded by John R. Mohler. When B. T. Galloway became Assistant Secretary of Agriculture on March 17, 1913, William A. Taylor was made Chief of the Bureau of Plant Industry. Henry S. Graves, Chief of the Forest Service, became dean of the Yale Forestry School on April 15, 1920, and was succeeded by William B. Greeley. E. W. Nelson followed Henry W. Henshaw as Chief of the Bureau of Biological Survey on December 1, 1916. L. W. Page, Director of the Office of Public Roads, died on December 9, 1918, and his successor was Thomas H. MacDonald. Leon M. Estabrook followed Nat C. Murray on July 1, 1914, as Chief of the Bureau of Crop Estimates. Charles J. Brand was Chief of the Office of Markets from May 16, 1913, to June 30, 1919, when his place was taken by George Livingston as Acting Chief. W. J. Spillman left the Office of Farm Management August 31, 1918, after which E. H. Thomson was Acting Chief until April 1, 1919, when Henry C. Taylor became Chief. In the Division of Publications Joseph A. Arnold was succeeded by Edwy B. Reid on July 16, 1918.

CHANGES IN ORGANIZATION

Secretary Houston attempted to bring about as far as possible a segregation of regulatory, research, and extension work within the several bureaus, and also secured from Congress authority to make a partial reorganization of the Department, which went into effect July 1, 1915. To deal with the Department's business in its relations with the State agricultural colleges and experiment stations, a States Relations Service was established with A. C. True as Director. This included the Office of Experiment Stations (except the Irrigation and Drainage Investigations, which was transferred to the Office of Public Roads), Offices of Extension Work in the South and in the North and West (transferred from the Bureau of Plant Industry), and an Office of Home Economics. The work on poisonous plants was transferred from the Bureau of Plant Industry to the Bureau of Animal Industry, which also received the work on duck diseases from the Bureau of Biological Survey. Soil fertility investigations went from the Bureau of Soils to the Bureau of Plant Industry, and those on wood distillation from the Bureau of Chemistry to the Forest Service. The Office of Public Roads became the Office of Public Roads and Rural Engineering and took over work on rural architecture from the Bureau of Plant Industry. In 1919 this Office become the Bureau of Public Roads. On July 1, 1915, the Office of Farm Management was transferred from the Bureau of Plant Industry to the Office of the Secretary and on July 1, 1919, became the Office of Farm Management and Farm Economics. An Office of Markets was created July 1, 1913, became the Office of Markets and Rural Organization July 1, 1915 (taking over work on farm credits and insurance from the Bureau of Plant Industry, and on market milk, poultry, and eggs from the Bureau of Animal Industry), and on July 1, 1917, was made the Bureau of Markets.

In 1919 the Division of Publications was enlarged to include the Office of Information created in 1913, the Office of Exhibits created in 1918, and the Motion Picture Laboratory.

The Federal Horticultural Board, established under the act of August 20, 1912, became an important regulatory organization during this period.

FEDERAL LEGISLATION AFFECTING THE DEPARTMENT'S WORK

The Agricultural Appropriation Act of March 4, 1913, gave the Department authority "to acquire and diffuse among the people of the United States useful information on subjects connected with the marketing and distribution of farm products." This led to the establishment and rapid development of the Office of Markets. In his annual report for 1916 Secretary Houston was able to say that "today the Nation possesses in this department the largest and best trained and supported staff of experts dealing with the distribution of agricultural commodities and rural organizations to be found anywhere in the world." The results of the studies and collection of information by this Office brought about a series of important Federal laws in the field of agricultural economics.

The first of these laws was the Cotton Futures Act of August 18, 1914, reenacted with amendments in the Agricultural Appropriation

Act of August 11, 1916. Under this act standards for cotton were established and the operations of the futures exchange were supervised. In the act of August 11, 1916, the United States Grain Standards Act was also included. This act authorized the Secretary of Agriculture "to investigate the handling, grading and transportation of grain and to fix and establish * * * standards of quality and condition for corn (maize), wheat, rye, oats, barley, flaxseed, and other grains." Grain shipped in interstate or foreign commerce must be inspected and graded by inspectors licensed under this act. The same appropriation act included the United States Warehouse Act, which provided for the licensing of warehouses for the storage of cotton, wool, grains, tobacco, and flaxseed, and for warehouse receipts which might be used as negotiable paper. This act promoted the better storing of farm products and encouraged the standardization of storages and of marketing processes.

The Federal Aid Road Act of July 11, 1916, provided for cooperation between the Federal Government and the States in constructing rural post roads and roads and trails in the national forests.

The Department was also active in promoting financial measures suited to the needs of the farming people and had much to do with securing the passage of the Federal Reserve Act of December 23, 1913, and the Federal Farm Loan Act of July 17, 1916.

In the Agricultural Appropriation Act of March 4, 1913, the Department was given authority to adopt regulations and fix closed seasons for migratory game and insectivorous birds according to zones of temperature, breeding habits, and times and line of migratory flight.

This act also included the Virus-Serum-Toxin Act, making it unlawful to manufacture, sell, or ship interstate any worthless or contaminated biological product for use in the treatment of animal diseases. Viruses, serums, toxins, or analogous products for interstate shipment must be prepared in establishments licensed by the Secretary of Agriculture and such products when imported must have permits for entry.

The Department was given special functions in connection with vocational education by the passage of the Smith-Lever Agricultural Extension Act of May 8, 1914, and the Smith-Hughes Vocational Education Act of February 23, 1917. Under the latter act the Secretary of Agriculture became a member of the Federal Board for Vocational Education.

As a war measure the Food Production Act of August 10, 1917, was intended to provide "for the National security and defence by stimulating agriculture and facilitating the distribution of agricultural products." It gave the Secretary of Agriculture authority to gather information on the supply and distribution of foods, feeds, seeds, fertilizers, and agricultural implements and machinery, and to purchase and sell seeds to farmers at cost. Funds were provided under this act for the fiscal year 1918 as follows:

For the control of livestock diseases and pests, enlargement of livestock production, and the conservation and utilization of meat, poultry, dairy, and other animal products, $885,000; for the purchase and sale of seeds, $2,500,000; for the control of insects and plant diseases injurious to agriculture, and the conservation and utilization of plant production, $441,000; for the collection of information on

supply, distribution, and utilization of food, on preventing waste of food, and for enlarging the market news service, $2,522,000; for the salaries of two assistant secretaries, special work in crop estimating, aiding the States in supplying farm labor, enlarging informational work, and printing and distributing emergency publications, $650,000; and for increasing food production and eliminating waste and promoting conservation of food by educational and demonstrational methods through county, district, and urban agents, and others, $4,348,400.

With variations in the amounts for different purposes, the total appropriation under this act was practically duplicated for the fiscal year 1919.

As the result of the passage of the new acts described above and the continuation of the previous acts for the control of foods, drugs, animal and plant diseases, and insect pests, the regulatory work of the Department was greatly enlarged during this period.

The service work of the Department, which had been steadily growing in amount and variety, was very greatly increased during the World War, and included much aid given to other Government departments, to the national and State councils of defense, to the Food Administration, and to many other organizations throughout the country. The following are examples of the special war services:

The Weather Bureau sent forecasts and warnings to army camps and naval bases and to railroads in connection with the handling and transportation of food and other supplies.

The Bureau of Animal Industry stressed meat inspection, the eradication of cattle ticks, and the use of anti-hog-cholera serum, accredited herds of cattle free from tuberculosis, supplied the War Department with mallein for testing horses for glanders, and helped to remove large numbers of cattle from drought-stricken sections of Texas.

The Bureau of Plant Industry secured and supplied seeds for over 1,000,000 acres in 1918.

The Forest Service aided the agencies needing forest products for war purposes in obtaining supplies of wood suited to their various requirements.

The Bureau of Chemistry aided the Quartermaster's Department and the Sanitary Corps in obtaining good supplies of food and other materials.

The Bureau of Soils stressed soil surveys where these would be of greatest service under war conditions.

The Bureau of Entomology aided the War Department in combating insects injurious to the health of men and animals and furnished to economic entomologists throughout the country information on prospective outbreaks of insects injurious to staple crops.

The Bureau of Biological Survey greatly increased the destruction of predatory animals and injurious rodents as an aid to the production of livestock and food crops and the protection of food supplies and other property.

The Office of Public Roads supervised the road construction at army posts and cantonments and greatly promoted the building of good roads under the Federal Aid Road Act.

The Bureau of Markets established telegraphic market news service for fruits, vegetables, grain, hay, seeds, milled feeds, livestock,

and dairy and poultry products, made surveys of food supplies and fertilizers, and purchased and distributed large amounts of nitrate of soda.

The Office of Farm Management aided many communities to obtain farm laborers.

The extension work of the Department was greatly increased under the Smith-Lever Act of 1914, the Food Production Act, and related legislation. The extension specialists of the bureaus made arrangements for service in the States through the States Relations Service, with its two offices of extension work covering, respectively, 15 Southern States and 33 Northern and Western States. With appropriations of $4,348,400 in 1918 and $6,100,000 in 1919 under the Food Production Act, in addition to the Smith-Lever and other funds, the States Relations Service was enabled to cooperate with the States in employing county agricultural agents in over 2,400 counties, home demonstration agents in about 1,700 counties and 200 cities, and nearly 3,000 administrative officers and subject-matter specialists. About 2,000,000 boys and girls were enrolled in the extension clubs. The Department and State forces thus organized were very important factors in stimulating the production of foods and other agricultural products required for war purposes and aided in large measure the work of the Food Administration in food conservation and distribution.

The extension system received the permanent support of the farming people after the war and, with somewhat reduced funds and forces, continued to operate throughout the country, dealing widely with the problems of production, marketing, and conservation of agricultural products and the interests of the farm homes. (For details of extension work see A History of Agricultural Extension Work in the United States, 1785–1923, by A. C. True, U. S. Dept. Agr. Misc. Pub. No. 15, October 1928.)

In July 1913 the Department publications were reclassified. The bureau series of bulletins and circulars were discontinued. The 40 or more series of publications were reduced to four, as follows (1) department bulletins, (2) periodical publications, (3) annual reports, and (4) farmers' bulletins.

In the fiscal year 1914, 1,152 new publications were issued, including 55 farmers' bulletins. The total number of copies printed was 26,691,692, to which were added 11,494,700 reprints. The appropriation for printing and binding was $490,000.

In 1918, with the aid of war emergency funds, 2,205 publications were issued, and copies of new publications and reprints aggregated 97,259,399.

In 1920 the new publications numbered 589, of which 61 were farmers' bulletins. The funds for printing and binding aggregated $675,000. At this time scientific and technical workers were encouraged to publish in professional journals, and 739 articles were so published that year.

The periodical publications included the Journal of Agricultural Research, Experiment Station Record, Monthly Weather Review, Monthly Crop Reporter, Public Roads, Weekly News Letter, and Market Reporter. Lantern slides were sent out in large numbers, especially to teachers and extension workers. A motion picture labo-

ratory had been established, and by June 30, 1920, the Department had 460 reels on 112 agricultural subjects. That year the Office of Exhibits made exhibits at 62 fairs in 36 States.

Between 1913 and 1920 the total number of books, pamphlets, and maps in the Department Library increased from 127,819 to 155,142 and the number of periodicals from 2,035 to 2,757. The main catalog contained about 430,000 cards.

EXPERIMENTATION AND RESEARCH

The new lines of investigational work by the Department during this period were mainly economic. During the war research was restricted to a considerable extent and dealt largely with matters relating to food production and conservation. Serious difficulties were often encountered in maintaining important lines of research because of the large overturn of personnel. Well-trained and experienced investigators were taken out of the Department in considerable numbers by the superior claims for their services in war enterprises and thereafter by offers of much larger salaries in private work. Nevertheless, the experimental and research work of the Department continued to be great in variety and extent. Only brief accounts of some of the more important investigations can be given here.

Weather Bureau.—Observations in the upper air by the Weather Bureau were much extended by the establishment of stations for this purpose in different parts of the country. Investigations on solar radiation were conducted in several regions. The collection of data on earthquakes was begun December 1, 1914, and studies in volcanology were undertaken in Hawaii in 1919. A Division of Agricultural Meteorology was organized in 1916 and studied the influence of weather on development of crops and the relation of frost to fruit production.

Bureau of Animal Industry.—The Bureau of Animal Industry continued investigations on infectious abortion, with special reference to the ways in which the infection gains entrance into healthy animals, where the infection localizes and propagates in the animal body, and how diseased animals eliminate the causative organism.

Much time was devoted to studies of ways in which hog cholera is spread and to devising a method for producing clear and sterilized anti-hog-cholera serum.

The so-called swamp fever of horses was studied with special reference to its cause.

Stomach worms of sheep were studied with reference to methods of preventing losses among lambs and sheep. Numerous anthelmintics recommended for the removal of worms from various host animals were tested and where found effective were studied with reference to the therapeutic dose and the proper technique and procedure in administering.

Bacteriological studies resulted in devising methods for disinfecting hides against anthrax spores.

Investigations of trichinae in pork showed that the parasites were killed when the pork was kept at a temperature not exceeding 5° F. for 20 days. The thermal death point of trichinae was determined to be practically 137° F. Other investigations resulted in practical

methods of curing various kinds of uncooked pork products which destroyed the vitality of trichinae.

Investigations on poisonous plants were continued, mainly at a well-equipped station on the Fishlake National Forest near Salina, Utah.

Extensive experiments on the immunization of fowls against fowl cholera were conducted. Studies of the gape disease of poultry showed that the gapeworm may infect turkeys of all ages, while chickens are susceptible to infection only while very young.

In animal husbandry, breeding and feeding experiments with horses, sheep, cattle, and poultry were considerably extended. Systematic experiments on the cause and prevention of soft pork were undertaken. The relative merits of wood and concrete silos were tested, and the effect of the silage on the concrete was determined. The bacteriology of meats in cold storage was studied.

Dairy research included investigations on milk secretion, bacteriological and chemical studies of milk, butter, cheese, and ice cream, and research in the utilization of byproducts. The relation between the phosphorus and calcium compounds of the blood of the dairy cow and her feed and the secretion of milk was studied, and it was shown that the milk yield was limited by inability of the cow to get sufficient minerals from the feed. Many experiments with bacteriological control were made on the ripening of Swiss and Emmenthal cheese, the manufacture of Roquefort and Camembert cheese, and the making of Cheddar cheese from pasteurized milk.

Bureau of Plant Industry.—The Bureau of Plant Industry expanded its organization and continued investigations on a broad scale on a large number of problems in plant production. The work was done in laboratories in Washington, at Arlington Farm, and at a large number of field stations in different parts of the country, particularly in the South and West, and to an increasing extent in cooperation with the State agricultural experiment stations. Search for varieties of plants which might prove useful in the United States was continued, especially in China, Africa, Central America, and South America.

The testing of new varieties and the improvement of varieties by selection and breeding were carried on with many kinds of plants and in many regions. Much work on the culture, harvesting, storage, and transportation of various crops was also done. Some examples of this work follow.

Cotton growing on a considerable scale was established in Arizona and in the Imperial and San Joaquin Valleys of California, and improved varieties were developed or introduced for this purpose. Meade, an upland long-staple variety developed by the Bureau, replaced to a certain extent sea-island cotton in Georgia and South Carolina. Much experimental work was done on the control of the branching of cotton, methods of thinning and spacing, and the growing of single stalk plants.

An improvement in the ear-to-row method of corn breeding was made by restricting the pollen parents in the breeding plats to ears known to be of high productiveness. A beginning toward securing strains tolerating self-pollination was made in experiments with a variety grown by the Pawnee Indians. Hybrids of corn and teosinte were produced. Tentative commercial grades of corn were worked out.

Field investigations with wheat were made as a basis for classifying commercial varieties, and much work was devoted to the histories, geographic distribution, descriptions, and synonyms of nearly 1,000 varieties. The effects of different methods of seeding on the winterkilling of wheat were studied. Australian varieties were found well adapted to dry-land conditions in the Pacific Coast States. Many crosses were made in efforts to produce rust-resistant varieties.

Breeding barley to secure awnless varieties was only partly successful. Inheritance studies indicated that the agricultural varieties of barley have resulted from natural hybrids. Various physiological studies of the barley kernel were made.

Many varieties of soybeans were introduced from China, Manchuria, Japan, Chosen (Korea), and Africa, and valuable varieties were produced in the United States by selection and breeding. Soybean production in the United States was greatly aided by experiments with seed of promising varieties for food and oil production and with different methods of culture and harvesting.

Alfalfa growing was promoted by introducing varieties from Peru, India, and other countries and by breeding hardy and drought-resistant strains.

Sudan grass was tested in many places, and much accurate knowledge about its culture and uses was accumulated. Pure seed was grown on a considerable scale.

The origin of potatoes as a cultivated crop was traced in 1913 to the high Andes region of Peru and Bolivia, and more than 250 sorts of cultivated and wild potatoes were secured for use in breeding work. Improvement of varieties by selection and breeding, studies of the adaptability of varieties to conditions in different parts of the country, classification of varieties, development of improved seed stocks, and cultural experiments were continued during this period.

Much work was done on the development of disease-resistant strains of tobacco. Experiments with fertilizers and lime were also carried on in the flue-cured tobacco districts of Virginia and the Carolinas and in other districts in Maryland, Tennessee, and New York. The relationship of tobacco to other crops grown in rotation, with reference to quality and yield, was also studied. A method of harvesting tobacco by picking the leaves from the stalk instead of cutting the stalk at its base was introduced by the Bureau in a portion of the flue-cured tobacco territory.

Improvement of varieties of flax by selection and breeding was given much attention. When war-time conditions materially reduced the supply of fiber flax there was much effort to produce varieties in the country as a basis for greatly expanding the growing of flax for fiber. Marked differences in the vigor of plants, and in height, resistance to disease, yield, and character of fiber were secured, but the increase of seed of improved strains was necessarily slow.

Investigation of the problems of dry-land agriculture in the Great Plains was broadened, the number of stations doing such work was increased, and much information covering a great variety of subjects was accumulated.

Horticultural investigations covered a wide range and included work on vegetables, fruits, and nuts, with a limited amount of work in floriculture. New kinds and varieties were introduced, varieties

were improved by selection and breeding, and experiments in culture, storage, and utilization of products were made.

Sweetpotato varieties were comprehensively studied with reference to their classification, adaptation to different regions, and utilization for various purposes. Much work was done also on handling, curing, and storing this crop.

A study was made of peanut varieties as a basis for selections to produce strains adapted for oil making or for human food.

Experiments were made in forcing and storage of vegetables, and in the ripening and handling of tomatoes in Florida as related to their storage.

The dasheen was successfully grown in the South, and a limited market for it was developed in northern cities.

Breeding of blueberries was continued, and in 1920 it was reported that about 15,000 hybrid plants produced in the greenhouses in Washington had been grown to fruitage in the plantation at Whitesbog, N. J. Four of the hybrid varieties, on which the largest berries were three-fourths of an inch in diameter, were placed in the hands of nurserymen.

Extensive experiments were made with muscadine grape varieties, including pollination, grafting, pruning, and training tests. Hybridization with other types of grapes yielded a very valuable collection of seedlings. Hermaphrodites, self-fertile and of higher quality, were produced. Investigations into methods of preparing sirup, grape juice, jelly, catsup, marmalade, and jam, were then undertaken. It was shown that varieties differed markedly in their usefulness for these purposes. The results from experimental vineyards in California, covering work during 12 to 15 years on resistant varieties, adaptability, and productivenes, made a good basis for further investigations on grape growing.

Experiments with American bunch grapes at Vineland, N. J., confined chiefly to the use of fertilizers, pruning, and other cultural problems, supplied material for utilization investigations, particularly on the value of different varieties in making unfermented juice.

The handling and storing of apples were extensively studied in the Northwest and California. The investigations included methods of harvesting, grading, and packing, stage of maturity at which apples should be harvested, promptness of cooling and temperatures in the storage houses, and the relation of tree vigor to the keeping quality of fruit in storage. The design, construction, and management of common or air-cooled houses were also studied.

Bud selection for the propagation of citrus trees in California proved to be of great practical importance, and investigations on this subject were continued. Many records of the performance of individual trees were accumulated, and these confirmed the previous conclusion that the characteristics of the parent tree are perpetuated in the progeny. The importance of selecting for propagation buds from limbs of known bearing proclivities was demonstrated.

The successful growing of the date palm in Arizona and California led to investigations of means for the rapid propagation of offshoots which showed that under partial shade and with controlled humidity a large percentage of offshoots would root.

Varieties of avocados from different sources were tested in Florida and California. The tests led to the selection of a few as most

promising. Experiments with varieties from Guatemala, which are thicker skinned and hardier than those from the West Indies, demonstrated the usefulness of a variety known as Fuerte.

Experiments in bulb growing showed that with careful culture the production of bulbs of tulips, narcissuses, hyacinths, and lilies might be made commercially successful in certain localities in the United States.

The work with nuts, principally with pecans, included investigations of the range of the species, adaptability of varieties to different regions, methods of propagation, soil improvement, orchard management, and methods of harvesting, curing, packing, and handling the product.

Investigations on the water requirements of plants, especially under limited rainfall, showed marked differences not only between different species but also between varieties of the same crop. Millet, sorghum, and corn required the least water, alfalfa and other legumes required the most, and wheat and other small grains formed an intermediate group.

The nature of organic soil constituents and the chemistry of humus were investigated. Several organic acids and toxic substances related to the decay of organic matter of soils were isolated. The relation of calcium salts to the physiological availability of the mineral soil constituents was studied.

Changes in fertilizer composition and practice due to war conditions led to experiments to determine the best sources and combinations of fertilizers on different types of soil. Experiments were made with potash from various American sources. The effects on the growth of plants of borax in the potash deposits from Searles Lake in California were determined experimentally, as well as the effects of reducing or eliminating the potash in fertilizer mixtures for potatoes and cotton.

Investigations of the effects of light on plant development (*72*) led to the discovery that the seasonal length of day—that is, the duration of the daily light period—is a factor of first importance. As a result of these studies it was found possible to establish the relationship of the length of day to early and late maturing varieties of crop plants, the relative development of the vegetative and fruiting portions of the plant, the distribution of the growing and the fruiting periods through the year, the condition of "everblooming" or "everbearing", the adaptation of different varieties and species of crop plants to different latitudes, and the natural distribution of plant species. Electric light was successfully used as a supplement to sunlight, and by artificial control of the daily light period the vegetative, flowering, and fruiting periods were suppressed or brought into expression at will. Thus plants were grown without bearing fruit or were made "everbearing."

Considerable time was devoted to experiments and studies of the possibility and economic practicability of making paper from cornstalks, flax straw, various hemp products, sorghum bagasse, and cotton stalks. While the possibility of making various kinds of paper from these products was demonstrated it was not found practicable on a commercial scale.

Investigations were made on the causes, life history, and control of numerous plant diseases, including, among others, smuts, rusts, scab, take-all, and black chaff of wheat; tuber rots, leaf roll, mosaic, powdery scab, leak, and wart of potatoes; dry rot, foot rot, and stem rot of sweetpotatoes; black rot, bitter rot, powdery mildew, and canker of apples; stem rot of watermelons; and mosaic, anthracnose, and angular leaf spot of cucumbers.

Citrus canker was first reported to the Bureau in the summer of 1914. It spread rapidly and became a serious menace to the growing of citrus trees in Florida and the Gulf States. The Bureau determined its cause to be a new species of bacteria (*Pseudomonas citri* Hasse) and conducted experiments on methods of control. Destroying infected trees was the only sure way of eradication, but formalin treatments of infected soil and spraying of groves exposed to infection proved useful supplementary measures. The Bureau participated in a strong campaign of eradication which was largely successful.

White pine blister rust was first found attacking native pines in North America during the fall of 1915 in Massachusetts and New Hampshire. General scouting in the next 5 years showed that this disease was prevalent in New England, New York, and Wisconsin. It was also found that the infection was carried over from wild and cultivated currants and gooseberries and other species of the genus *Ribes*. Federal and State quarantines were established, and campaigns were conducted for the eradication of *Ribes* plants.

Nematode investigations were continued throughout this period.

Forest Service.—The Forest Service continued and enlarged its silvicultural and dendrological studies, including a wide range of work on the botanical characteristics of trees and forests as related to their protection, reproduction, and growth. Silvicultural conditions on farm wood lots were also investigated. Special field studies of eastern oaks and Rocky Mountain conifers were made.

Forest-management experiments were made on methods of marking trees and on systems of cutting, thinning, and disposal of brush. The causes of success or failure in natural reproduction of forests were investigated. The effects of forests on stream flow and soil erosion were studied, as well as methods for preventing erosion and rapid run-off on watersheds supplying irrigation water. Fire-protection studies included such problems as the amount of protective effort warranted by the character and amount of the timbers and forage in the forest and its usefulness as a watershed, the prediction of dangerous conditions, and means of fire prevention, detection, and control.

Surveys of farm wood lots were made, with special reference to their relation to the rest of the farm and the methods of utilizing and marketing the wood.

Under reforestation, numerous investigations were made regarding the sources and extraction of seed, nursery practice, and the methods and seasons of planting and sowing. The effects of altitude, soil, age of species, density of stand, and other factors on the character of the seed were studied, as well as the relation between the germination of seed in the greenhouse and in the field.

Continued studies of forest products at the Madison, Wis., laboratory and elsewhere included tests of timber strength (which by 1920 aggregated 500,000), the manufacture of alcohol from wood waste, methods of rendering wood fireproof, the properties of wood preservatives, and methods of manufacture of various products to increase their yield. Studies on the resistance to decay of the wood of many species of trees were made, as well as investigations regarding the manufacture of wood pulp and paper, including the utilization of low-grade wood and of bark for these purposes.

During the participation of the United States in the World War and thereafter much attention was given to problems in the construction of airplanes. Tests and experiments were made on different kinds and treatments of wood for propellers and other parts of airplanes, on the laminated construction of certain parts, on the development and use of waterproof glues and coatings, and on the influence of drying and steaming on the strength of timber for airplanes.

Problems in the utilization of the ranges within the national forests were widely studied. More than 5,000 species of range plants were collected and identified and their life histories, distribution, and forage values were investigated. Experiments were made in protecting ranges from excessive grazing and in artificially reseeding depleted ranges. The management of cattle and other animals on the ranges, the distribution of their watering places, the relation of grazing to forest fires, and the utilization of forests by communities on the ranges were among the other matters studied. Much of the range work was carried on at a station in the Manti National Forest in Utah.

Bureau of Soils.—The Bureau of Soils continued the systematic prosecution of the national soil survey and made special studies of great soil groups with reference to crop production and of soils as related to special crops, as for example, apples and truck crops. The Bureau also isolated and identified a large number of organic compounds in different soils. Greenhouse and field experiments with a considerable number of these compounds were conducted, the results showing that some were beneficial to plant growth, some were harmful, and others had no effect. The origins of these soil compounds were also investigated. The role of fertilizer in mitigating the harmful effects of toxic soil compounds was studied. Chemical studies on the mineral composition of soils showed their great complexity. Plant ash was examined for rare elements.

Investigations of the fertilizer resources of the United States were undertaken at the beginning of this period and became increasingly important as the World War progressed. The Bureau began to study the fixation of atmospheric nitrogen, and in 1914 laboratory apparatus for experiments with the Haber process was installed at Arlington Farm. Work on this subject was afterwards carried on in a larger way in cooperation with the War Department, which also had a laboratory at the American University. The investigations were expanded to include the preparation and use of cyanamide and the fixation of nitrogen by means of the silent discharge.

The Bureau's most important work relating to phosphatic fertilizer was the investigation of furnace processes for volatilizing and

collecting phosphoric acid in concentrated form. It was shown that the electric furnace can be successfully employed in volatilizing the acid and that the Cottrell precipitator will collect the acid thus evolved. Experiments were then undertaken in the use of a fuel-fed furnace, and such a furnace of semicommercial size was installed on Arlington Farm.

A large amount of experimental work was done in the production of potash from kelp, which is found in great quantities on the Pacific coast. An experimental plant located at Summerland, Calif., began operations and thereafter produced potash and other products from kelp on a considerable scale.

In cooperation with commercial concerns investigations were also made in the recovery of potash in the manufacture of cement and in the operation of blast furnaces.

Bureau of Chemistry.—The Bureau of Chemistry made investigations during this period on a great variety of subjects, partly in cooperation with other bureaus and partly on its own account.

The composition of vegetable proteins and the forms in which nitrogen occurs in plants were studied. This work included the proteins of peanuts, kafir, and buckwheat flours; globulins of peanuts, velvetbeans, coconut, and buckwheat; and the gelatins. It also covered the nitrogen distribution in cotton and tomato seed, cowpeas, corn, and wheat. The composition of many varieties of soybeans were determined with reference to the variation dependent on variety and climate.

The saponins in a number of specimens of yucca and *Agave* were studied, and the essential oils of varieties of mustards were determined. Examinations of the North American species of the genus *Ilex* revealed the presence of caffein only in *I. vomitoria*. An extensive survey of the composition of cottonseed from various sections of the country was made. The nature of the odorous constituents of apples was determined.

In continuation of the work on sugars and sirups, new sugars were discovered; the preparation, mutarotation, and rotating power of sugars and sugar derivatives were investigated; and methods of manufacturing cane and sorghum sirups were improved.

Microchemical, chemical, and baking investigations on the various grades of flour were undertaken. These investigations were supplemented by studies and experiments with various products used as partial or complete substitutes for wheat flour in making bread. It was found possible to make good flour and bread from einkorn, emmer, spelt, and Polish wheat. Studies on the milling and food value of rice byproducts and on natural brown and polished rice were made. Baking experiments were also made with bread in which rice flour prepared from different varieties and grades of rice was mixed with wheat flour.

Investigations relating to citrus byproducts were continued in a more systematic way at the laboratory at Los Angeles, Calif., and in cooperation with manufacturers. Methods of making marmalade, vinegar, and candied peel from cull oranges were developed, as well as methods of making candied peel and juice from grapefruit. Methods for manufacturing citrate of lime and citric acid were improved and adapted to California conditions.

Concentrated cider and cider sirup were made from surplus and cull apples. The changes that cider undergoes during fermentation and prolonged storage and its subsequent conversion into vinegar were also studied.

Problems in drying fruits and vegetables, especially potatoes, received much attention. Waterproofing leather, absorption of oils by wet and dry leather, methods of increasing water resistance of sole leather, various solvents for the extraction of oils and grease, and the effect of humidity on the tensile strength of leather were studied.

A laboratory of microbiology was established to further develop work on the decomposition and fermentation of food products. A comparative study of groups of species of molds was undertaken with reference to their habitats and the changes induced by them in foodstuffs. The organisms causing the spoilage of sardines and salmon were studied. Much attention was given to the problems connected with the poisoning of canned foods by *Bacillus botulinus*. Fermentation of pickles and sauerkraut was also studied.

The study of methods of analysis of a great variety of substances was continued.

Bureau of Entomology.—The Bureau of Entomology continued to carry on investigations on the broad plan previously described, but the work was considerably expanded in extent and variety. More detailed investigations were made on well-known insects of economic importance, with special reference to local conditions affecting their life history and control. A number of studies having more or less general application were also made. Among these were the investigations on the physiology of insects, the biology of mosquitoes, insects as carriers of plant and animal diseases, geographic distribution of fruit flies, relation of insects to forest fires, and the bioclimatic law of latitude, longitude, and altitude as applied to entomological and agricultural research and economic practice. In cooperation with the Bureaus of Plant Industry and Chemistry many proprietary insecticides were studied and tested, as were other insecticides developed by the Bureau of Entomology or others for use alone or in combination with fungicides.

Investigations on the habits and control of the alfalfa weevil, which during this period spread from Utah to Idaho and the Pacific coast and eastward to Wyoming and Colorado, were continued. A successful and cheap method of spraying was devised.

An outbreak of the range caterpillar in New Mexico led to a special appropriation in 1913 and several years of active introduction of parasites from European and American sources.

The European corn borer was discovered near Boston, Mass., in the late summer of 1917. By immediate cooperation of Federal and State entomologists, scouting to determine its spread and a study of its habits and means of control were undertaken. The next year it was found in the Mohawk Valley, N. Y., and in New Hampshire. By 1920 it had spread to western New York and northern Pennsylvania. Eggs were found on a number of garden crops and larvae on beets and beans. The rate of flight was measured. Parasites from France were brought to Massachusetts in the autumn of 1919, and in 1920 a laboratory for the propagation of parasites from France and Italy was established at Auch, France. Machinery was devised for de-

stroying cornstalks, stubble, and weeds in infested fields. On July 24, 1919, Congress made $250,000 available for work on the corn borer, and on July 7, 1920, $400,000. These amounts were in addition to funds provided by the States.

Investigations on the boll weevil were continued and greatly expanded. Early hand picking of weevils and squares was found to be of little use. It was found that dusting with arsenate of lead or calcium arsenate could successfully be done on a large scale. Power machines for this purpose were devised and tested. Much work was done on the life history and field biology of the weevil. Experiments were also made with varieties of cotton, date of thinning, and the spacing of the plants as related to weevil injury.

Experiments in control of tobacco insects demonstrated the usefulness of powdered arsenate of lead for combating the hornworm, flea beetle, and budworm. Power machines were devised for dusting the plants with this insecticide. Spraying with a solution of nicotine sulphate and soap was found effective for the thrips. Storage of tobacco at low temperatures prevented injury by the cigarette beetle. The discovery that the mosaic disease of tobacco was carried by insects of several species led to studies in their control.

An extensive study of the life history and means of control of the codling moth as affected by differences in climatic conditions was made in different parts of the country. Life-history studies of apple-tree borers were made. Special attention was given to the roundheaded borer, and it was found that the service tree and a few other forest trees were very largely responsible for the distribution of this insect. Biological studies of several species of apple aphids were made, especially with reference to the exact determination of alternate food plants and the identity of certain forms. Experiments were made on the relative merits of liquid and dust sprays for apple trees and on the combined use of fungicides and insecticides in sprays for plant diseases and for biting and sucking insects.

The discovery that the Japanese beetle was established near Riverton, N. J., led to the setting up there in 1918 of a laboratory for biological and other studies of this insect, which feeds on many fruits, vegetables, ornamentals, forest trees, and weeds. Means of control adopted included quarantine and barrier bands of dusted or sprayed foliage. Experiments with cyanide of soda and other chemicals were made and parasites were introduced from Japan.

Investigations on the use of hydrocyanic acid gas for fumigating citrus trees in California were resumed in 1913 to improve methods of fumigation and to determine the agencies responsible for fruit injury during fumigation. The discovery that liquid hydrocyanic acid might be used led in 1918 to work on economical production of the liquefied gas and to field experiments to determine the best methods of use and to eliminate the risk of poisoning workmen. The diffusion of the liquefied acid under various temperatures and the effect of the gas on the citrus trees as the temperature was reduced were studied.

The fear that the Mediterranean fruit fly would be introduced into continental United States led Congress to make an appropriation for its investigation and control, available in August 1912. In cooperation with the Federal Horticultural Board, a laboratory was

established at Honolulu, Hawaii. Life-history studies were undertaken, with special reference to the relation of the insects to various hosts, notably bananas, pineapples, coffee, taro, coconuts, and citrus fruits. Parasites were introduced, and observations were made on the effect on the fruit fly of these and other natural enemies.

The life histories of pecan insects, such as the leaf case bearer, shuckworm, and budmoth, were studied, and experiments with arsenical liquids and dusts were made.

Studies of a number of potato insects, including the tuber moth, Colorado beetle, flea beetle, aphis, and leafhopper, in different parts of the country, related to the distribution of these insects, their spread, and their control by climatic conditions, natural enemies, and chemicals. Insects injurious to cabbage, including the looper, western flea beetle, harlequin bug, diamond-back moth, maggot, and aphids, were also studied.

An important line of investigation of forest insects was a study of the character and extent of damage caused by tree-killing bark beetles and methods of controlling them in some of the principal national and private forests of the Pacific slope and Rocky Mountain regions. Many experiments in treating commercial wood products with chemicals to prevent insect damage were made.

Work relating to the gypsy moth continued throughout this period. In addition to scouting, quarantine, and control operations, the feeding habits of the insect were studied in the laboratory and the field. The distance to which the larvae were carried by the wind was determined. A wilt disease of the gypsy moth and later a bacterial caterpillar disease from Japan were studied. Parasites were introduced and colonized, and their spread and effects were observed. The thinning of woodlands and the use of wood from infested trees were studied on experimental tracts. Experiments were made in tree banding and in spraying with chemicals, and high-power spraying apparatus was devised and used.

The biology and methods of control of insects injuring stored products were investigated. Among the insects studied were weevils, attacking rice, corn, beans, peas, and cowpeas, and the Angoumois grain moth. Gases as fumigants were tested, especially naphthalene, hydrocyanic acid gas, and dichlorobenzene. The effect of heat and cold on such insects was tested, as well as the feasibility of controlling them with electricity. Insect-proof cartons for cereals, breakfast foods, and dried fruits were devised. Methods of sterilizing milled products and dried fruit were tested.

Work on malaria mosquitoes was continued and a monograph on the species of *Anopheles* in North America, South America, and the West Indies was issued. Observations and experiments were made in Louisiana on the life history, habits, and control of malaria mosquitoes under plantation conditions. House flies in dwellings, packing houses, and manure piles were studied with reference to hibernation, breeding, and means of control. Baits attractive to flies were studied and improved traps were devised. Different types and grades of screen wire were also studied.

The most important investigations in bee culture were on problems connected with wintering the bees and the control of foulbrood.

Bureau of Biological Survey.—The Bureau of Biological Survey continued investigations on the same general plan as previously. A biological survey with special reference to the geographic distribution of plants and animals was conducted in Alabama, Alaska, Arizona, Florida, Georgia, Montana, North Dakota, Oregon, Washington, Wisconsin, and Wyoming. Studies of the food habits of North American birds included examination of the stomachs of many species. Special attention was given to wild fowl and fish-eating birds. The relation of birds to injurious insects, especially the boll weevil, alfalfa weevil, and range caterpillar, was also considered. The distribution and habits of moles, skunks, pocket gophers, and large game animals were investigated. Experimental breeding and raising of minks and martens was undertaken, and this work was later developed to include some other animals at an experimental fur farm in Essex County, N. Y. In connection with the enforcement of the Migratory Bird Act a systematic study of bird migration was made. There were also special studies of the birds of Puerto Rico and the Canal Zone and publications on the mammals and birds of New Mexico, the birds of Texas, and the mammals of Panama, together with a monograph on marmots.

Office of Public Roads.—The Office (from 1919, Bureau) of Public Roads continued investigations on road construction and maintenance, including special studies of concrete and bitumens. It also made economic investigations relating to road management, results of road improvement, and county road systems. From July 1, 1915, the irrigation and drainage investigations, transferred from the Office of Experiment Stations, were continued. The work in irrigation included experiments and studies on the duty of water, pumping, flow of water in different types of conduits, and the efficiency of reservoirs, appliances, and equipment. Drainage studies on the movement of moisture in soils, the run-off from agricultural land, the capacity of the drains and other conduits, the relative flow of water in clay and cement tile, and the drainage of muck soils were made.

Office of Experiment Stations.—The office of Experiment Stations continued its studies on agricultural education, irrigation, drainage, and human nutrition, as previously described, until July 1, 1915, when it became a part of the States Relations Service. From that time its research work was confined to the operations of the Federal agricultural experiment stations in Alaska, Hawaii, Puerto Rico, Guam, and (from Jan. 1, 1919) the Virgin Islands. At the Alaska Stations increased attention was given to breeding experiments, including those with vegetables and fruits at Sitka, cereals at Rampart, and cattle at Kodiak. Field experiments on a farm scale were conducted at Fairbanks and at the station established in 1917 in the Matanuska Valley. Grain grown at these stations was distributed to farmers in their vicinity, and in 1919 a flour mill with a daily capacity of 25 barrels was erected at Fairbanks.

At the Hawaii Station soil studies were continued. A way was found to control certain pineapple troubles, due to abnormal soil conditions. Experiments were made with fertilizers for bananas. Breeding was done with pineapples, papayas (for fruit), mangoes, avocados, tomatoes, sweetpotatoes, corn, and pigeonpeas. It was found that budding hastens maturity of avocados and mangoes. A

plant-disease laboratory was established, and diseases of potatoes, celery, bananas, pineapples, sugarcane, taro, and rice were studied. Successful experiments were conducted in making pineapple vinegar, in drying fruits, and in manufacturing starch from cassava, edible canna, and taro.

The Puerto Rico Station continued investigations on soils and their improvement with legumes and fertilizers. Special studies were made on the absorption of iron by the rice plant and on selective absorption by plant roots. Rotation and fertilizer experiments were made with sugarcane. Emphasis was laid on work with citrus fruits, mangoes, coffee, vanilla, cacao, and coconuts, including testing and breeding of varieties and culture experiments. Work in plant pathology included diseases of these plants and of beans, tomatoes, potatoes, and sugarcane. The entomologist studied insects affecting coffee, trees shading coffee, and stored grain, as well as the changa and cattle ticks. Breeding of animals was continued, and experiments were made with silage from kafir, Sudan grass, Napier grass, cane tops, and velvetbeans.

At the Guam Station tests of varieties of a considerable number of vegetables, fruits, and field crops were made, and there were some experiments in improvement of varieties by selection. Among the crops grown were corn, rice, cowpeas, soybeans, sorghums, cotton, and tobacco. Para grass and *Paspalum dilatatum* proved to be useful grasses in Guam. Pot experiments were made with crops and fertilizers on some peculiar soils, and the cause of the infertility of newly plowed land was investigated. Purebred horses, cattle, swine, and chickens were introduced, and breeding and feeding experiments with them and the native livestock were conducted.

In the Virgin Islands the experiment station maintained by the Danish Government on the Island of St. Croix was transferred to the United States Department of Agriculture on January 1, 1919, and the experiments with field crops, fruits, and vegetables were continued. Variety tests and breeding and culture experiments were made with sugarcane and corn, and breeding experiments with cotton. Leguminous crops for forage and green manures were also tested. An entomologist was added to the staff and undertook a study of scale insects, as well as experiments in the control of insects injuring vegetables and other plants.

Office of Home Economics.—The Office of Home Economics in the States Relations Service continued food and nutrition investigations transferred from the Office of Experiment Stations and extended work relating to clothing, textiles, and household management, labor, and equipment. An experiment kitchen was established in which work on various problems relating to food preparation and use was done. The digestibility, nutritive value, culinary qualities, and use of animal and vegetable fats and the home canning and drying of fruits and vegetables were investigated. In wartime special studies of the digestibility, preparation, and use of wheat substitutes were made. A broad survey of the dietaries of people in different parts of the country was conducted in cooperation with the Bureau of Markets. Experiments on the energy expended in household labor were continued in the large respiration calorimeter and the small calorimeter was further used for experiments relating to the ripening

of fruit, incubation of eggs, and wintering of bees. There was also a limited survey of labor conditions in farm homes. Methods for prolonging the wear of clothing and household textiles and on the treatment and care of wooden utensils, furniture, and floors were studied.

Bureau of Crop Estimates.—The Bureau of Crop Estimates further developed its system of monthly reports on crops and livestock. It added truck crops to the products reported on, and by 1917 it was giving estimates for about 70 crops and classes of livestock. It also reported the actual enumeration of sugar crops in the continental United States and in Hawaii. It materially increased its statistical record of acreage and production of crops in foreign countries and of international trade in agricultural products, computed in United States weights and measures. Many special studies were also made and reported, such as historical statistics of rice, tobacco, hops, and cotton, wages of farm labor, cost of producing cotton, acreage of principal crops in 1866–1915, value of farm products for 21 years, geographic variations in farm prices, and quantities of various crops fed to livestock in 1918.

Office of Markets.—The Office (from July 1, 1917, Bureau) of Markets from its beginning in 1913 was planned to collect and diffuse information covering comprehensively the field of marketing farm products. Specialists in nine branches were appointed during the first year of the operation of the Office. This organization was further developed as funds increased. During this period the investigations were largely of the survey type and were made with a view to accumulating definite information on existing conditions in the marketing of farm products and on related subjects. Often these studies were made to lay the foundation for necessary legislation or to aid in the enforcement of regulatory laws. Under the head of livestock, meats, and wool, studies were made of the relative efficiency in marketing beef cattle, hogs, and sheep in the central and local markets of various regions. Typical shipments of cattle and hogs were followed from the farm through the stockyards, packing houses, and wholesale and retail markets to the consumer, and the cost of transportation, selling, and slaughtering of the animals was ascertained, as were the expenses of distributing and retailing the meat, including factors of loss and cost of storage and delivery.

Detailed studies of the cost of distributing meats and meat products through retail stores of different types were made. On the basis of an investigation of commercial wool grades, tentative standards for grading wool were worked out. Milk-marketing conditions, including the sources and amount of available supplies and methods of distributing milk and cream, were studied. Special attention was given to the management and operation of city milk-distributing plants and those operated by farmers' cooperative companies. The marketing of butter, cheese, and milk powder was also studied. Many problems relating to the economic factors in harvesting, handling, packing, loading, transporting, storing, and distributing fruits and vegetables were studied. Studies of precooling plants, refrigerator cars, icing stations, heater cars, and containers were also made. Much work was done on the development of standard grades for apples (in barrels or boxes), peaches, potatoes, sweetpotatoes, onions, cabbages, tomatoes, and other vegetables.

Spinning tests of different varieties of cotton were made; standards for various types of lint and for cottonseed and linters were worked out; the effects of exposing baled cotton to the weather were studied; and the construction, management, and operation of warehouses were investigated. Primary markets were surveyed, and the organization and operation of cotton exchanges were investigated.

The handling, storing, and grading of grain were studied. Standards were worked out for corn, wheat, barley, oats, rye, grain sorghums, rice, and flax. Studies were made of the moisture content and gross weight of wheat stored at the terminals and at country points, the milling and baking qualities of various types of wheat and flour, smut eradication, cleaning grain on the farm to reduce dockage and foreign material content, and the prevention of dust explosions in threshing machines.

The marketing of seed and hay at country points, terminal markets, and in consuming territories was investigated. The need for an inspection service and for standard grades for hay was thus brought out. During the war a broad survey was made of the country's food supply in storage, in the hands of manufacturers and dealers, and in households. The per capita consumption of food was also determined. For several years direct marketing of farm products through the parcel post and express was studied, and many experimental shipments through these agencies were made. For example, in 1920 it was reported that 568 such shipments of 16 different commodities had been made during that fiscal year.

At the beginning of its work the Office of Markets made a general survey of cooperative marketing organizations in the United States and in 1914 reported that it had a record of more than 8,500 marketing associations, about 270 cooperative and farmers' elevators, 2,500 cooperative and farmers' creameries, and more than 1,000 cooperative fruit and produce associations. Many of these associations were, however, imperfectly or only nominally cooperative. This survey was made the basis of a continuing study of the organization, management, operation, financing, accounting, and business practices of cooperative organizations for selling farm products or buying farm supplies and equipment. The laws of the various States and of foreign countries relating to cooperative farm organizations were collected, digested, and studied.

The Office of Markets began the study of matters in the field of rural organization. Such work was continued and somewhat further developed after the title was changed to Bureau of Markets in 1917, but in 1919 this work was transferred to the Office of Farm Management. Up to that time it had included studies of rural credit, insurance, telephone companies, and some social and educational activities in rural communities.

Office of Farm Management.—The Office of Farm Management continued the collection, analysis, and interpretation of records relating to the different factors in farm business. Thousands of records were obtained on farms of various types in different parts of the country. These records showed the economic results of general farming or of specialized farming for the production of cotton, wheat, sugar beets, tobacco, beef or dairy cattle, swine, sheep, poultry, and fruits. The analysis dealt with the size of the farm business, its

quality as shown by the returns per animal unit and by crop yields, its diversity, its adaptability to local conditions, and its stability, i. e., the utilization of labor and machinery throughout the year. The relative time spent on crops, livestock, and general work was also determined. Studies were made on the cost of growing different crops and livestock and on different systems of farm bookkeeping and cost accounting. The relation of farm machinery and other equipment to crop yields and to labor requirements and efficiency was investigated as well as problems connected with the growth of farm tenancy and the changes in systems of tenant farming.

Among special studies were those on land settlement in the cut-over regions of Michigan, Minnesota, and Wisconsin; the relation of land tenure to range control in Arizona and New Mexico; and hail insurance. Beginning in 1919, the Office made farm-life studies on the social aspects of tenancy and farm sales, the history of certain farm communities during the past century, and the differences in the social life of farm communities as related to the types of farming.

AGRICULTURAL EXPERIMENT STATIONS AS AFFECTED BY THE SMITH-LEVER EXTENSION ACT AND THE WORLD WAR, 1914–20

LARGER OPPORTUNITY FOR UNINTERRUPTED RESEARCH

Until the United States entered the World War in 1917 the State experiment stations had in many respects their greatest prosperity. The more complete organization of the extension services at the land-grant colleges as the result of the passage of the Smith-Lever Extension Act of May 8, 1914, relieved the experiment stations from a considerable amount of routine work in the popular dissemination of agricultural knowledge. While the number of station workers who did extension work did not materially decrease, their duties in this direction were more largely confined to matters directly connected with their station work, and they often had more time and freedom to engage in research.

In summing up the general status of the stations in 1916, the Office of Experiment Stations pointed out the larger opportunity for uninterrupted research and the better organization of the station work with a more constructive purpose and more definite plan. In larger measure investigations were selected to meet the special requirements of the agriculture of the several States and were undertaken with more realization of the necessity for their continuous prosecution until definite results were obtained. It was stated that—

> The inspection work has become a much less conspicuous feature at the stations and has been so organized as to avoid interference with investigation and experiment. Facilities for publishing the technical and research activities of the stations have materially increased. * * *
>
> But this enlarged research activity has in no way affected the ultimate purpose of the stations or their definite application to the vital practical problems of the agricultural industry. Through the extension divisions the stations maintain a more direct contact with agricultural practice than ever before, and because they furnish the stock in trade for the extension teaching it is evident that they must make their work more searching and enlightening—not only in practical results but in the understanding of them (*9*).

The stations were also drawing closer together in planning their work, and there was an increasing amount of cooperation among themselves in the conduct of investigations. They were going beyond

this in some cases by cooperating with universities and other institutions. Nearly every experiment station had cooperative arrangements with the United States Department of Agriculture in one or more projects.

ORGANIZATION AND PERSONNEL DIFFICULTIES

The demand and the absolute necessity for a greatly increased agricultural production in the United States to meet the needs of the country's military forces and of the nations allied with it in the World War in 1917 and 1918 brought throughout the country a great awakening to the practical importance of the results of the station and Department researches (*7, p. 5*). Without doubt the more thorough application of these results, combined with the wider use of improved machinery and the sacrificial labors of the people left on our farms, brought about a production of food and other agricultural necessities which was more than enough to meet the war requirements. But the effort to accomplish this and to do other things essential to winning the war produced a profound effect on the organization and work of the stations.

Great numbers of the administrative officers and scientific and other employees were taken away entirely or in part from the service of the stations. A considerable number entered the military service voluntarily or as the result of the draft. Others went into technical or industrial employment more or less connected with the war. Station directors served as important members of State councils of defense and in some cases as State food administrators. Many members of the station staffs did important work on State councils of defense, and on commissions or committees on food supply or other matters, as well as with Federal or national organizations, such as the Food, Wool, and Fuel Administrations, fertilizer and milk commissions, National Research Council, and Red Cross, or they were active members of committees of scientific societies which were organized to advise or assist in wartime enterprises. Some were taken into the greatly expanded extension service as county agents or in other capacities. Those who did not leave the station service were often drafted in connection with a great variety of wartime campaigns and the supervision of war gardens.

In spite of such conditions the stations managed in one way or another to recruit their forces, though often with less experienced or more superficially trained men. Much attention was given to the research problems in the immediate needs of agricultural production. On the whole, the number of projects seriously interrupted or entirely abandoned was comparatively small.

The close of the war did not bring an end to the difficult situation regarding station personnel and work. Station salaries were much lower than those in other occupations for persons with similar technical training, and the cost of living continued very high. Many men therefore felt obliged to leave the station service, however regretfully. The prosperity of agriculture immediately after the war and the inability to see that this would not continue, brought many additional students into the agricultural courses in the land-grant colleges. In part this was due to the new opportunities for service as teachers in the high schools receiving Federal and State funds under the Smith-Hughes Vocational Education Act of 1917 and to the

effort to provide agricultural training at the colleges for disabled war veterans. The general result was to increase the teaching load of a considerable number of station workers in the years 1919 and 1920. The great popularity of the agricultural extension work and its expansion during the war caused it to overshadow to a considerable extent the work of the stations and made it more difficult for them to secure the additional State funds which the enhanced cost of their operations demanded. For the time being, agricultural research in the land-grant colleges did not receive the attention it deserved, being held down by the insistent pressure of the teaching and extension work.

The personnel situation in the stations in 1919 was clearly brought out in the report of the Office of Experiment Stations for that year, as follows:

> From 1914 to 1919 the directors of practically half the stations changed, in five cases twice. Eight of the former directors went into industrial positions. Furthermore, it may be noted that of the 28 administrative changes which occurred, the vacancies were filled in all but three cases by persons who had not had previous experience in directing an experiment station; one-half of them were likewise new to station work, not having been connected with a station staff, and only a small part had been previously engaged in active investigation of any type (*7, p. 6*).

In nine cases the station directorship, formerly a separate office in the college, was combined with that of president, dean, or director of extension. For the 6-year period up to 1919 the personnel turn-over of the stations was 80 percent. That is, nearly 1,400 persons in technical positions, out of a total of approximately 1,700, changed their positions, and a large proportion of them went outside the stations.

> There was a decline of about 250 persons in the combined station staffs. While the assistant grade was most largely represented in these separations, 370 department heads and leaders of special lines made a change, equivalent to an average of 7 leading workers for every station. Of this expert class, upward of 150 went into industrial or commercial lines, about 50 into extension work, an equal number to the National and State departments of agriculture, and nearly as many more into exclusively teaching positions (*7, p. 7*).

In some stations the decrease in the number of assistants required the leaders of projects to do so much simple routine work that the progress of research was severely handicapped. The large overturn of personnel continued through 1920 when the directors were changed in 7 stations and over 50 heads of departments resigned, as well as many employees of lower rank.

In the fiscal year 1915 the total number of administrative and technical workers in the stations was 1,857, of whom 892 were also engaged in teaching and 466 in extension work. In 1920 out of 1,968 station workers, 1,137 were also teachers, and 436 were extension workers.

ADDITIONS TO INCOME AND EQUIPMENT

The total income of the stations for the year beginning July 1, 1914, was \$5,286,382, and 6 years later it was \$7,660,570. The annual Federal funds were not increased during this period, the State appropriations grew from \$2,129,604 to \$3,786,997, the inspection fees from \$343,087 to \$359,964, and the receipts from sales of farm products from \$514,220 to \$1,167,856. These increases were, however, much more than offset by the decline in the purchasing power of

the dollar. Moreover, the State appropriations often included funds for inspection or extension work. Only 8 stations had income from inspection work. Out of the receipts from farm products, after expenses of operation of the farms were paid, little money was left for research. The Office of Experiment Stations estimated that the income of the stations in 1919, which was available for administration, experimentation, and investigation, was practically limited to Federal and State appropriations, together with less than $270,000 derived from miscellaneous sources. In the year beginning July 1, 1920, the stations in Minnesota, Ohio, Texas, and Wisconsin each received over $200,000 from the State, 11 stations had from $100,000 to $200,000, 13 from $50,000 to $100,000, 8 from $25,000 to $50,000, 4 from $10,000 to $25,000, 4 less than $10,000, and 6 had no State funds.

An average of about $1,000,000 was annually spent during this period for additions to station equipment. Of this amount about $400,000 was used for buildings. In this period, however, few large buildings were erected at the stations.

Increased costs made it impracticable in many cases to purchase much-needed land, apparatus, equipment, or livestock, or even to replace or repair old equipment.

The number of substations or somewhat permanent experimental farms greatly increased. In 1920 there were 130 such establishments in 30 States. In addition, many experiments were carried out in cooperation with farmers.

INCREASED USE OF THE PROJECT SYSTEM

Planning and recording the station work in the form of projects of limited scope became general. In some cases this was carried to excess, and the station records were padded with statements regarding small enterprises or those on which very little actual work, if any, was done. In the main, however, this method of recording work served a very useful purpose and increased the definiteness of the station enterprises.

For the calendar year 1920 the Office of Experiment Stations compiled the first fairly complete list of station projects. The total number of projects submitted was 4,219, of which 155 were carried on by the Federal experiment stations in Alaska, Hawaii, Puerto Rico, Guam, and the Virgin Islands. Of the 4,064 projects conducted by the State stations 555 were on the Adams fund and 3,479 on the Hatch and other funds. The average number of projects for the State stations was 81, with 11 on the Adams fund and 70 on the Hatch and other funds. Grouped under the more general headings there were 1,468 projects in agronomy, 639 in horticulture, 587 in animal husbandry, 344 in diseases of plants, 340 in entomology, 199 in dairying, 164 in veterinary medicine, 113 in rural economics, and 13 in rural sociology. Since most of the work in rural economics had been inaugurated during this period, it is interesting to note that of the projects included under that head 52 were on accounting and cost of production, 25 on farm organization and management, 17 on marketing, 6 on land tenure, 5 on land values, 5 on farm labor, 2 on land settlement, and 1 on rural credit.

PROGRESS IN DIFFERENT LINES OF WORK

The scope and general character of the work of the stations were not materially changed during this period though the number of projects was considerably increased. In its report for 1918 the Office of Experiment Stations published a summary of the main lines of work of the stations (*6*). As this illustrates very well the work carried on during this period it is presented herewith, with some changes intended to adapt it to the period as a whole.

AGRICULTURAL CHEMISTRY

Among the more strictly agricultural chemical inquiries may be mentioned studies of the organic matter in soils; the occurrence of phytin phosphorus in plant products and the function of organic phosphorus compounds in feeding stuffs for swine; the fixation of phosphoric acid in soils; the relation of phosphorus in the soil and in the crop, especially in wheat; and of the chemical composition of certain crops to phosphorus deficiencies in the soil. An important investigation which arose out of emergency conditions and was conducted cooperatively by a number of stations, was the study of methods of converting raw phosphate rock into an available form, by composting with sulphur and other materials. Other chemical subjects investigated included the relation of soil and fertilizer constituents to plant growth, the magnesium and sulphur nutrition of plants, the proximate constituents of plants and the requirements of plants for lime and magnesia, the decomposition of calcium and magnesium carbonates in soils and their influence in conserving soil sulphur, and studies of the limestone deposits in the various States.

Detailed chemical studies were conducted on the form of nitrogen in the nodules of legumes, the effect of pressure on enzyms, the composition of butter fat, Sudan grass, grain sorghums, and the apple; the process of silage making from legumes, the gluten colloids of wheat, the poisonous principle of the cotton seed, and food decomposition and poisoning. Studies relating to the methods of preserving food included the home canning of horticultural products, the drying of fruits and vegetables, and the curing of meats.

Other chemical studies dealt with improved methods of clarifying sugar cane juice, particularly with the use of decolorizing vegetable carbons; the deterioration in storage and losses in sugar manufacture due to bacteria, yeasts, and filamentous fungi; the elaboration of maple sugar, with the starch and sugar content of maple leaves and wood; prune ripening; and the isolation of citric acid from milk.

METEOROLOGY

Meteorological observations were made at many of the stations, to supply data for experiments in progress. At one station an attempt was made to determine a temperature law in crop production. There were also various studies on the influence of meteorological factors, single and combined, upon crop production.

SOILS

Bacteriological investigations included studies in nitrification and the conditions which affect it, sulfofication in relation to ammonification and nitrification, nitrogen fixation, especially the carbonaceous food requirements of the organisms, bacterial changes in soils due to different methods of treatment, effect of green manure on the soil bacterial flora, and factors influencing bacterial activity in soils. The relation of organic matter to the bacterial content, their mutual relation to productive capacity of the soil, and the relation between the bacterial flora and the composition of the soil were also studied. Other topics of investigation were the effect of organic matter on the longevity of *Bacillus radicicola*, the bacterial decomposition of organic matter and manures, soil inoculation for legumes, influence of soil treatment on the phosphorus content and availablity, and the nitrogen cycle in acid soils.

Soil fertility studies were directed toward methods of maintaining and increasing productive capacity, including such subjects as the influence of rotations on soil fertility and methods of maintaining fertility by this means and

by the use of commercial fertilizers, manures, and green manuring crops, and the effects of fertilizers and crops on soils. Some stations made special studies of the infertile soils of their States and methods of improving these, also of the potential fertility of the soils. Improved methods of soil management were under investigation, the methods of draining and cropping peat and muck lands, the decomposition of organic matter, and the availability of the nitrogen in such soils.

Soil acidity received much attention, including the effects of liming on the assimilation of nitrogen by crops and the action of lime in the decomposition of organic matter in soils. Investigations on the composition and constituents of the soil included studies of the effects of exhaustive cropping on the chemical composition, the availability and utilization of plant nutrients in soils under different methods of treatment, the action of soil alkalis, and the treatment of alkali soils with sulphuric acid. The relation of sulfofication and nitrification to the phosphorus in soils, sulphur in relation to soils and crops, the effects and interreactions of lime and organic matter on rock and acid phosphates in soils, the rôle of manganese in soil fertility, and the availability of potash in subsoils were other important subjects of investigation.

Projects on the nitrogen in soils included studies of the effects of green manures and of bacterial action; nitrate production in soils, its development and control; the effect of electrical stimulation on nitrogen fixation; and the accumulation of nitrogen and carbon in soils under different systems of management.

Work in soil physics included studies of soil moisture constants, water percolation, evaporation, erosion, and run-off; the availability and conservation of soil waters; the relation of soil moisture to crops; moisture as affected by cultural practices; the composition and variation of the soil solution; and the rate of solubility of soils under different treatments and conditions.

Systematic soil surveys were carried on in many of the States, including the location of the principal soil types; chemical studies of the various types; and field, plat, and pot experiments on representative soils to determine their fertilizer and lime requirements.

FERTILIZERS

Extensive fertilizer experiments on various crops were carried on by most of the stations and included such topics as the use of fertilizers in rotations and the best time to apply them, and comparisons of nitrogen, phosphoric acid, potash, and lime from different sources and in different combinations. A great deal of work was done on the use of raw ground rock phosphate and on the relative value of different forms of phosphoric acid and the rate of its application on various crops. Investigations were also made on the availability of rock potash and other domestic sources of potash, on sodium as a partial substitute for potash, on means of conserving potash, and on the relative availability of different forms of nitrogenous fertilizers.

AGRICULTURAL BOTANY

Among the subjects studied were plant correlations related to yielding capacity, the effects of pollen from barren stalks of corn, the effect of environment on the rice plant, botany of *Lespedeza striata*, the distribution and eradication of wild garlic, and the function of sulphur and chlorin in the plant.

Extensive investigations on the principles of plant breeding and the application of the laws of inheritance to special crops were carried on at many of the stations. There was a large amount of breeding and selection work aiming to improve varieties, secure immunity from disease, or emphasize some valuable character, such, for example, as increased oil content of the soybean. Breeding work was done on a large variety of plants, including fruit trees, small fruits, field crops, grain, and vegetables, in part by botanists and in part by agronomists and horticulturists.

Investigations in plant physiology included studies on such subjects as the reactions of enzyms to solutions within the plant; enzymatic activity as a limiting factor in productivity; the conditions prevailing in plants during dormancy and the relation of that period to their future development; the wintering of cherry buds; the relations of nutrition, temperature, and moisture to variations and mutations; the development of fruit buds; the cause of the off year in fruit bearing; and the forcing of plants with various chemicals. The injurious effect

of abnormal food supplies and certain organic compounds in the soil on plant growth was under investigation, as was also the poisoning and stimulating effects of insecticides and fungicides. A study was also made of the decomposition products of plant growth toxic to plants, the organisms that cause the decomposition, and the after effects on plant growth. Much work was done on seed treatment of cereals and other crops in its physiological relations.

FIELD CROPS

Practically all of the stations carried out tests of varieties, fertilizers, rotations, and methods of seeding and culture, and did work on the improvement of crop plants by selection and breeding, and on the development of disease-resistant strains. A number of the stations studied the adaptability of new varieties to different sections of the State and the economic utilization of native food plants.

General subjects under this head included the influence exerted on plants by previous growth of other kinds of plants, the mineral requirements of crops, especially in the critical periods of growth, the water requirements of crops and its more economical use, the effect of lime on different crops, and the limiting factors in crop production. Investigations were made on seed-bed preparation, intertillage, and methods of weed eradication.

With the more important field crops, as, for example, corn and cereals, a large amount of experimental inquiry was carried on. Variety, cultural, and fertilizer tests were made to meet local needs, but in addition there was a large amount of work upon improvement by breeding, selection, hybridization, and acclimatization. Among problems dealt with in the latter studies were the correlation of inherited characters, the feasibility of increasing the content of certain constituents, such as fat or protein, the duration of the effects of inbreeding, and effect of inheritance on sucker formation, pigmentation, etc. The principles governing the growth and maturity of corn, the distribution of stand and its adjustment to soil types and conditions, the effect of variation in the character and composition on the vigor of the plant, and interplanting with legumes were among other special lines of study. The growth and harvesting of corn for silage, including varieties, stage of maturity, and growing with legumes, also received attention. The storage of various crops, with a study of conditions and their effects, was the subject of much inquiry.

Cotton investigations included breeding with special regard to the relation of lint to yield; studies in inheritance; selections to secure early, high-yielding strains and wilt resistance and to develop a high protein and oil content; factors influencing earliness and resistance to wilt and drought and to boll-weevil conditions. The cause of the shedding of young bolls, the effect of continuous culture, place and climatic variations, variety tests, rate of planting and spacing, cultivation, depth of plowing, topping and harvesting, treatment of seed, and the effect of storage on the vitality of the seed were also under investigation.

Emergency conditions directed special attention to studies of the cereals. Extensive work was conducted on the milling and baking qualities of standard wheat varieties and the relation of the soluble protein to the baking strength. Studies were also made of inheritance, the influence of environment on the wheat plant, its response to different plant foods, the relation of its composition to soil types, the relation of potash to the growth of cereals, and the influence of soil and culture on the nitrogen content and yield of wheat.

Other work with wheat included studies of the biochemical changes in frosted wheat; tests of varieties, cultural methods, dates and rates of seeding and seed selection; and variation in winter wheat. Selection experiments were under way to secure improved grain, cover-crop, and pasture strains of rye and barley; to develop flour and beardless winter varieties of barley; and to secure an awnless variety of oats resistant to rust and winterkilling. The milling of grain sorghums and their use as substitutes for flours and meals made from corn and wheat were active lines of experiment.

On Irish and sweet potatoes there were variety and culture tests and many fertilizer experiments. Such special problems as storage conditions, the effect of high-yielding hills on the progeny, selection for improved strains, thinning experiments, factors influencing seed production, a comparison of northern and southern grown seed, the effect of locality on the yield, various breeding experiments, and the germination of seed for the second crop commanded much attention. In sections where rice and sugar cane are grown, variety, cultural,

and fertilizer tests were carried on, with the introduction and propagation of promising new varieties. Some very important work was done in the production of sugar-beet seed.

A number of experiments on tobacco were under way, including breeding, fertilization, transplanting, variety tests, priming versus cutting, curing, and rotation systems for tobacco growers.

The importance of the alfalfa crop directed the attention of a number of stations to it in cultural, variety, fertilizer, and other investigations. Extensive experiments with sweetclover were also in progress. The velvetbean is rapidly coming into prominence as a field crop for the Southern States, and various phases of its production were studied at a number of stations, such as methods of gathering and handling the crop and the production of early maturing varieties. The peanut crop also received considerable attention by the southern stations. The culture and improvement of the soybean and its feeding value for animals and man, as well as the saccharin and nonsaccharin sorghum varieties as forage crops, were studied.

The depleted condition of many of the western ranges has led to extensive studies on the relative importance of native-range forage plants and their reestablishment, as well as the introduction of foreign varieties, and studies on poisonous range plants and methods of decreasing losses due to them. The feeding value of yucca and other forms of native vegetation in the Southwest for carrying cattle over long seasons of drought was an important line of experiment.

Various pasture experiments were carried on relating to management and renovation, the care, fertilization, and treatment of grass lands, and the establishment and improvement of pastures; also methods, time, and rate of seeding grasses and grass mixtures for meadows and pastures, the effect of grazing on pastures, top-dressing mowings and pastures, and early spring crops for pastures. There was a large amount of work with forage plants of various kinds as to their adaptation, culture, and the like. The various phases of dry farming continued to receive much attention.

HORTICULTURE

Horticultural subjects engaged the attention of practically all the stations. Extensive experiments on fruit culture were under way, including variety and fertilizer tests, pruning, the relation of stock and scion, breeding and selection, the development of hardy varieties to withstand winter injury, cross-pollination, self-sterility and self-fertility of varieties, and other questions. Fall and spring planting of trees, the effect of dynamiting ground for setting trees, orchard tillage and cover crops, wood growth under different treatment, the dormant period of trees, fruit-bud development, factors affecting fruit production, and color in fruits were important topics of study. The harvesting, storage, and marketing of fruits received much attention.

Experiments of this sort were carried on with all the leading deciduous fruits. Citrus fruits were studied in regard to their food requirements and the relation of the fertilizer elements to certain citrus diseases. Investigations on nut trees, especially the pecan, were in progress at several of the stations. Projects on small fruits included variety and culture tests, improvement of the strawberry by crossing and selection, and the influence of continued self-pollination. A few stations made experiments in blueberry culture and several studied various questions arising in cranberry growing. Work on the grape included, in addition to variety tests, selection and breeding, and studies of the muscadine grape and the fecundation of the rotundifolia group.

In olericulture most of the stations conducted variety, fertilizer, cultural, and selection and breeding work with various vegetables. Rotation and cover crops in connection with vegetable growing in the field and greenhouse and storage and marketing problems were subjects of investigations. Some special lines of study were the storing of cabbage, breeding strains of asparagus resistant to *Fusarium* wilt, and other diseases, selection and isolation of types of squashes, improvement of the tomato by crossing and selection, factors affecting the setting of the fruit, and adaptability of varieties; inheritance of stringiness in beans, growing onions from seed, and various experiments with broccoli.

Experiments in floriculture and greenhouse management were carried on at several of the stations and included the production and the influence of the physical factors of the soil on the growth of carnations; breeding hardy roses

for the Northwest; a study of varieties, hardiness, adaptability, and breeding of roses, peonies, sweet peas, gladioli, phlox, and iris; and miscellaneous greenhouse experiments.

FORESTRY

Forestry assumed an added importance both from the military demands for lumber and from the necessary increase in the use of wood for fuel, due to the scarcity of coal. Practical farm forestry and the management of woodlots; wood utilization and commercial tree studies, including the marketing of forest tree products and the production of walnut lumber for use in the manufacture of aeroplanes and gunstocks were projects which received attention.

Other forestry projects included the establishment of forests of different species, the tolerance of forest trees, a study of the types of northern forests, with various forms of management; the utilization of the Adirondack hardwoods; forest arboretums, reforestation studies, and the propagation of forest trees; the introduction of new forest and shade trees; the planting of sand dunes; and testing varieties for ornamental, shade, windbreak, hedge, and building purposes.

DISEASES OF PLANTS

Plant diseases and their control were prominent subjects of investigation at practically all of the stations, especially the diseases of food and field crops. General subjects studied included the relation of soil moisture, temperature, humidity, and other factors to susceptibility and infection; mycology on several groups of parasitic fungi; the cause and control of individual diseases; the relation between parasitic fungi and their host plants; and the protection of farm and fruit crops against fungus diseases. Special groups of fungi and disease, such as sclerotia and *Fusarium* diseases, were under comprehensive investigation.

Among the orchard and fruit-tree diseases studied were the blight, brown bark spot, root rot, tree canker, blackheart, anthracnose, wood rot, peach yellows, plum pocket, and pecan disease. Citrus diseases received considerable attention, especially citrus canker and certain physiological troubles. Diseases of the raspberry and other small fruits received attention, also avocado diseases and pineapple wilt. Several stations carried on extensive studies on white-pine blister rust, white-pine root rot, chestnut-bark disease, and other troublesome diseases.

Much attention was given to cereal diseases, especially the rusts and smuts. Many stations carried on active campaigns in barberry eradication for the control of the rust, and much was accomplished in the development of varieties resistant to rust and smut. The fungi causing root troubles of grains were also studied. Among the numerous studies on cotton diseases were those on anthracnose and the causes of the dropping of young cotton bolls. Potato diseases received special attention at a number of the stations, including studies of the nature, cause, and control of tip burn, the relation of the character of the skin of the potato to scab, *Fusarium* and *Verticillium* wilt, and *Rhizoctonia* disease and slime mold, dry rot, and other diseases occurring in storage. Investigations of alfalfa diseases included selection and breeding for resistance, spraying, and treatment of the seed bed and other means of control. Diseases of sugarcane were studied where this crop is grown. Diseases of other field crops that were under investigation include frog-eye, mosaic disease, wilt, blight, and wildfire of tobacco; a bacterial disease of the soybean; peanut diseases; the diseases of clover and its resistance to anthracnose (*Colletotrichum trifolii*); the causes of flax wilt and the development of resistant strains; the cause and control of black rot, yellows, and blackleg of cabbage; and bean diseases, especially rust and its control.

Other investigations included bacterial wilt and *Fusarium* wilt of watermelons, biological and field studies of the wilt of tomatoes, onion diseases, lettuce diseases, celery diseases, cucumber mildew, root knot and "damping-off" in the seed bed, and diseases of ornamental plants and of canning crops. Extensive experiments were conducted on methods of seed treatment, especially the concentrated or dry formaldehyde method of treating oats and wheat, and the causes of seed injury, which were of special war significance. A number of the stations conducted plant-disease surveys in their States in cooperation with the Department of Agriculture.

ECONOMIC ZOOLOGY

Studies were carried on, especially in the western stations, on the control of injurious mammals, such as gophers, ground squirrels, and prairie dogs.

ENTOMOLOGY

Some of the more general subjects under investigation were the life history and methods of control of insects infesting cattle and swine, the cause of the periodical recurrence of insect pests, the destruction of hibernating insects in winter, parasitism as a factor in the control of injurious insects, activity as influenced by temperature and moisture, the progressive immunity of insects to insecticides, the control of insects by impregnating the sap of plants with poisons, and studies of groups or orders of insects, as, for example, the Aphidae.

Attention was given to body lice, mosquito control, and the tick transmitting spotted fever to man. The fever tick, the chicken tick and mite, the stick-tight flea, the life history and methods of control of the hog louse, and the stable fly were under investigation.

Numerous studies were made on shade tree and orchard insects (including those infesting the pecan), the white ant, the locust borer, and the sycamore lace bug. Other investigations included the habits and life histories of the codling moth, apple-plant lice, the apple-tree borer, the lesser apple worm, the apple-leaf roller; the reaction of the apple-leaf miner to applications of contact insecticides, and the control of late summer apple pests; insects injurious to nursery stock; the control of fruit insects by spraying and other methods of combating these pests; spraying for the San Jose scale, the woolly aphis, the peach-tree borer, and curculio; citrus insects, especially the control of the white fly by parasites and the white-fly-eating lady beetle; the pumpkin bug as a citrus pest; the pear-leaf blister mite; and the spinning sawfly of the plum.

Investigations on insects attacking wheat and other grain included those on the chinch bug and its control; the false chinch bug; the prevalence, distribution, and control of the Hessian fly, the wheat strawworm and the joint worm, the western wheat aphis, the wheat-head army worm, the wheat sawfly, and the stem maggot. Corn insects studied included the corn plant louse, the corn earworm, and the recently imported European corn borer. Cotton insects under investigation were the boll weevil, root louse, and stalk borer.

Other studies of insects attacking field crops included those on the rice weevil; the cowpea louse; clover insects; bean pests, including the bean beetle and the bean and pea weevils; alfalfa insects; the potato flea beetle; the sweet-potato weevil; sugar-beet insects, including the sugar-beet louse and webworm: and the velvetbean caterpillar. Work was also carried on with insects attacking the melon, means of control of the onion maggot, the Harlequin cabbage bug and cabbage worm, the slender wireworm, the tobacco worm, euthrips, control of nematodes, morphology of the plant lice and their relation to spinach blight, cranberry insects, grasshopper and cutworm control, the field cricket, the black fly, the economic importance of the digger wasp, and the control of the armored scales and the gloomy scale.

Investigations were actively pursued on insecticides and spraying material and apparatus, including especially such subjects as the burning of foliage by arsenicals, the toxic value and action of insecticides, a comparison of dust and liquid sprays, trials of new insecticides, the effect of cuprammonium washes and Bordeaux mixture, tests of spray nozzles, and methods of control by fumigation.

BEEKEEPING

Among the apicultural subjects studied were the wintering of bees; bee diseases, as, for example, honeybee paralysis; poisoning bees by spraying trees while in bloom; methods of extracting beeswax; the development of pure Italian queen bees; artificial impregnation of queen bees; the reproductive capacity of Carniolan and Italian bees; and surveys of honey-producing plants.

ANIMAL PRODUCTION

Studies in the field of genetics in regard to the laws governing inheritance in domestic animals contributed to the knowledge of principles controlling

descent. Extensive experiments were conducted in inbreeding dairy cattle and hogs, and on the biology of inheritance in dairy cows and poultry.

Other studies pertaining to livestock breeding touched on artificial impregnation, age as a factor in breeding, the effect of nitrogenous foods on breeding, experiments in the breeding of Polled Hereford cattle and strains of milking Shorthorns, the development of Holstein dairy herds, and herd improvement, as, for example, by the organization of breeding circuits. Considerable breeding work was carried on with horses, mules, and sheep. Experiments with hogs included the breeding of young sows and the effect of gestation and lactation on the growth and composition of swine. Poultry breeding work was especially directed toward breeding for egg production and the correlation of early maturity to egg production.

A number of projects on the care and management of livestock, relating to methods of feeding, handling, and housing, such as a comparison of range and confinement, management, and feeding as related to vigor of germ, were carried on.

There were extensive studies in the principles of animal nutrition and feeding, embracing such subjects as functions of the proteins and vitamins,[2] protein requirements for growing cattle, mineral metabolism, relation of quantity of rations to quality of the beef and pork produced, nutrition requirements for beef production, use made of food by animals of different ages, factors influencing the normal rate of growth of domestic animals, influence of nutrition during the growing period on subsequent performance, effect of a cereal diet on the blood, role of phosphorus in nutrition, nutritive value of locally grown feed, and effect of age on economy of gains.

The composition of various feeds and their digestibility and utilization by different classes of livestock were actively studied. Tests of various feeding stuffs and home-grown feed were conducted on an extensive scale, and during the war included new materials and waste products, such as garbage and cannery refuse. The growth of forage crops for pasturage and the feeding of various crops in the field to save labor, the use and value of silage made from corn and other crops, the employment of legumes to replace grain feeds in part, and the maintenance of stock, stressing the more extensive use of roughage with a lighter grain ration, were especially practical lines of experiment. Systems of management, finishing, and fattening of cattle and hogs in carload lots; and the amount of beef or pork an acre of land will produce with different rotations, were among the commercial problems studied. The work with beef cattle continued to be especially extensive and varied, covering all the important feeds, the quality of the product, loss in slaughtering, production of baby-beef, and the like.

Examples of work with swine were comparison of common crops for pork production, the use of forage crops in reducing cost, a comparison of limited and full feeding on different forage crops, the economy of "hogging-off" crops, the use of self-feeders, and the effect of various feeds on the quality of pork. An important project in swine feeding in the South was the hardening of peanut-fed pork with other southern-grown feeds, tests to determine to what extent peanut meal can be fed and still produce a hard pork, and experiments with peanuts, soybeans, and other southern grazing crops for hogs. The value of velvetbean meal as a substitute for corn and in connection with garbage for maintaining brood sows and the value of cottonseed meal as a hog food was studied. The factors involved in cottonseed-meal poisoning, and the avoidance or minimizing of this trouble continued to be under investigation. Tankage and other supplements for corn, and the value of rice products, were other subjects of experiment.

Experiments in the management and feeding of horses and mules, including the cost of raising farm horses and of feeding work stock, were carried on at some of the stations.

A number of the stations conducted investigations in sheep husbandry dealing with feeding and management, maintenance, and winter rations for breeding ewes. Experiments to establish a breed of sheep for winter lambing were in progress, as were studies of fall forage for fattening lambs; the rate,

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[2] There was rapid advance during this period in the use of small animals in studying the nutrition of man and domestic animals, especially with reference to the nature of vitamins and their function in nutrition.

economy, and character of gains made by lambs of different breeds and ages; the use of silage for lambs; and the fattening of range lambs. Experiments relating to the effect of various factors on wool production, to inheritance in wool production, to the effect of rations containing a high sulphur content on the fiber, and to the effect of alkalis and weathering on wool, and to methods of testing the fiber, were also carried on.

Poultry investigations included studies of the use and value of various feeds for production of eggs and market fowls, breeding for egg production, the effect of age and the influence of the male, animal foods for forcing egg production, a comparison of egg production from pullets hatched in February, April, and June, and the cost of egg production. The value of velvetbean meal and other protein feeds was tried, also various grain rations and substitutes for wheat for laying hens.

Experiments were made on the value of crate-fattening roasters; a comparison of cockerels, capons, and pullets for meat production; and on the cost of production of mature pullets. Studies were also made on the optimum conditions for artificial incubation, on incubation temperatures, the physiological zero point of germ development, the cost of hatching a chick, the growth of chicks, and rations for chickens. Other subjects studied included broodiness and methods of preserving eggs for winter use.

DAIRYING

Among the feeding experiments with dairy cattle may be mentioned tests of a great variety of grain feeds and combinations, byproducts, and waste products; a comparison of corn silage with sorghum silage; studies of the value and digestibility of sunflower silage and the value and method of feeding velvetbeans and velvetbean meal; and comparisons with soybeans, peanuts, and cottonseed meal.

The feeding value of mature as compared with immature corn, a comparison of alfalfa and red clover for milk production, the replacement value of legumes in dairy production, a comparison of the proteins in different feeds, and the protein and energy requirements for milk production were subjects of study. Other dairy feeding problems included winter rations for dairy heifers, a comparison of wide and narrow rations, the value of grasses and grass-like plants as pasture, various rotations with special reference to their value to the dairyman, the cost of raising dairy heifers, the role of water in the dairy-cow ration, and the value of dairy-bred steers for meat production in the dairy herd.

Extensive experiments in the feeding and raising of calves included a comparison of pasture-grass hay with sorghum silage for wintering weanling calves, the value of cottonseed meal for calves, their maximum and minimum protein requirements, and a study of the efficiency of milk substitutes.

Various projects relating to milk and its production, and to other dairy products were studied, such as composition and methods of testing, the management of dairy industries, and the most improved methods for production and marketing. Milk production problems included milk sanitation; the handling and delivery of market milk; the bacterial flora of milk; factors determining the value and influencing the composition of milk, especially the effect of different feeds; the proteins of cow's milk; the cost of producing market milk; and a comparison of milking machines.

Work upon butter had to do with its manufacture, composition, and marketing; chemical and bacteriological studies, especially in regard to its keeping qualities; and the causes of inferior butter and of fishy and other undesirable flavors. Studies in making and curing American and various fancy cheeses were also carried on. Commercial ice-cream making and the use of sugar substitutes in ice cream were also studied.

VETERINARY MEDICINE

Work relating to animal diseases and their treatment included the study of methods for the preparation of biological products for use in protecting animals against disease; the production and distribution of veterinary biological products, vaccines, serums, and bacterins for controlling contagious diseases of livestock; livestock sanitation; the role of immunity, inheritance, and transforma-

tions as a means of combating communicable disease in animals; and laboratory diagnosis.

Studies on contagious abortion included the immunization of horses and cattle by the use of serums and vaccines, the raising of infection-free offspring from infected parents, and the transmissibility of the disease to swine. Hog cholera received much attention at many of the stations, which not only carried out extensive vaccination for its control but made studies on the immunity of vaccinated hogs, immunity of suckling pigs, and the vitality of hog-cholera virus. Researches in connection with tuberculosis and the tuberculin test, especially as to the technic of the various methods and their accuracy, were in progress.

Other subjects receiving attention were immunization against blackleg and anthrax and the dissemination of the latter disease by insects, particularly flies and mosquitoes; botulinus, particularly in horses; equine anemia and swamp fever in horses and mules; hemorrhagic septicemia; the distribution, cause, and control of "milk sickness" or trembles; biting flies of cattle, including the ox warble fly, as spreaders of disease; necrobacillosis; various animal parasites; the cause and prevention of hairless pigs; and prevention and treatment of sterility in cattle. A number of southern stations took an active part in tick eradication. Investigations were in progress on swell head of sheep and goats; stomach worms, muscle parasites, and tapeworms of sheep; and the changing of pastures for the control of sheep parasites. Studies were made on mixed infections of swine and a disease causing paralysis of the hind legs. Poultry diseases under investigation included among others bacillary white diarrhea, fowl cholera, blackhead of turkeys, gapeworms, roundworms, and tapeworms of poultry.

Livestock poisoning by plants on ranges was an important subject of investigation at a number of stations.

RURAL ENGINEERING

Investigations in rural engineering were quite extensive, especially in connection with irrigation and the crops and rotations suited to this type of farming. Pumping for irrigation, irrigation for humid climates, water in relation to crops, the application of water, methods of using a limited water supply to secure the greatest crop production, the stage of growth at which water is most essential, the composition of irrigation waters, and ground-water development were studied at various stations; also the intensive cultivation of irrigated lands, and the utilization by dry-farming methods and by grazing of lands for which there is but a limited water supply.

Other engineering subjects included drainage, tractor farming, tillage implements, power machinery, farm structures and structural strength, silo construction, rural water supplies, farm sanitation and sewage disposal; also ice making on the farm, and the preparation of alkali-proof cements. Investigations were made on combustion and fuel consumption in sugar-house boilers, and means of introducing more efficient equipment and better boiler-house practice.

RURAL ECONOMICS

Studies in rural economics, including farm management, related to a comparison of livestock and grain systems of farming, a study of methods of farm practice, types of farming adapted to cut-over lands where beef and hog raising predominate, the distribution of farm labor, cost of living on the farm, systems of renting land, farm cost accounting, cooperative organizations for marketing and buying, agricultural insurance and credit, and public markets. The cost of production of various crops and of the products of livestock farming and the marketing and distribution of such crops and products were under investigation.

INSPECTION AND CONTROL

Inspection and control work was carried on as usual by many of the stations and covered fertilizers, seeds, feeding stuffs, human foods, and drugs; nurseries and apiaries; creamery licenses; and stallion registration. Special lines of control at some of the stations dealt with the white-pine blister rust, the gypsy moth, and mosquitoes.

AGRICULTURAL RESEARCH DURING THE AGRICULTURAL DEPRESSION, 1921–25

UNITED STATES DEPARTMENT OF AGRICULTURE

ADMINISTRATIONS OF SECRETARIES HENRY CANTWELL WALLACE AND HOWARD MASON GORE, 1921–25

Henry Cantwell Wallace (*318*) was Secretary of Agriculture in the administration of President Harding from March 4, 1921, to October 25, 1924. He was the son of Henry Wallace, founder and long-time editor of Wallaces' Farmer, who by his strong and attractive personality and through the broad character of his paper exerted great influence on the agriculture and country life of the Middle West. He was born at Rock Island, Ill., May 11, 1866, and was brought up on his father's farm in Iowa. He entered Iowa State College of Agriculture and Mechanic Arts in 1885, but left in his sophomore year to engage in farming in Adair County, Iowa, where he resided for 5 years. Returning to the State College in 1891, he graduated the following year with the degree of B. S. A. From 1893 to 1895 he was assistant professor of agriculture in charge of dairying at this college under James Wilson, afterwards Secretary of Agriculture. During this period he joined with C. F. Curtiss in conducting the Creamery Gazette, and Farm and Dairy. From 1895 to 1916 he was manager and associate editor of Wallaces' Farmer and then its editor until his appointment as Secretary of Agriculture on March 5, 1921. He was in thorough sympathy with his father in considering the economic and social interests of farming people as well as agricultural production. His last important contribution to agricultural literature was a book dealing with present-day economic problems of agriculture. This was entitled "Our Debt and Duty to the Farmer" and was published in 1925. He died at Washington October 25, 1924.

Howard Mason Gore was Assistant Secretary of Agriculture, 1923–24, became Acting Secretary of Agriculture on the death of Secretary Wallace, and was appointed Secretary of Agriculture on November 22, 1924, serving in that capacity until March 4, 1925. He was born at Clarksburg, W. Va., October 12, 1887, and became a successful breeder of Shorthorn, Hereford, and Jersey cattle and Berkshire hogs. He was Chief of the Trade Practice Division of the Packers and Stockyards Administration of the Department of Agriculture from 1921 to 1923 and then was appointed Assistant Secretary of Agriculture. After leaving the Department he became Governor of West Virginia on March 4, 1925.

Charles William Pugsley was Assistant Secretary of Agriculture, 1921–23. He was born at Woodbine, Iowa, August 12, 1878, and graduated from Woodbine Normal School and from the University of Nebraska, receiving there the degrees of Bachelor of Science in Agriculture in 1906 and Doctor of Agriculture in 1922. He was a teacher at Woodbine Normal School, 1899–1902, and served at the University of Nebraska as assistant professor of animal husbandry, 1908–9; professor of agronomy and farm management, 1909–11; professor of farm management, 1911–14; and director of agricultural extension, 1911–18. He was editor of The Nebraska Farmer from 1918 to 1922. He became president of South Dakota State College of Agriculture and Mechanic Arts on September 15, 1923.

CONDITIONS AFFECTING THE WORK OF THE DEPARTMENT

The period between 1921 and 1925 covered the worst of the postwar agricultural depression and extended through the partial and unsteady improvement of the agricultural situation, but closed before a satisfactory outcome had been reached. In his report for 1924 Secretary Wallace summarized the general features of this period as contrasted with the previous prosperity of agriculture, as follows:

> The depression struck American agriculture in a transition period. Within a decade it had increased its production 15 per cent, not by increasing the number of farm workers, but by increased efficiency. Rejuvenation of equipment was in full swing. Road horses were being exchanged for automobiles. Some regions were introducing tractor power. A great program of pure breeding and disease control was under way in the livestock industry. Farmers everywhere were pushing ahead to a better living standard.
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> All this development was checked by the postwar crisis. The increased productive efficiency which normally would have meant prosperity brought bitter fruit instead. Buying of new materials and replenishment of equipment stopped. Farmers ceased to buy tractors and depended on horsepower. Great herds of livestock were dispersed. The South was handicapped in its fight against the boll weevil. Standards of living were reduced. Farmers drew on their cash reserves and on the equity in their land, and debt accumulated. In short, the condition by the end of a decade of extraordinary progress in agricultural efficiency was the reverse of what might logically have been expected.
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> The depression which began in 1920 was not merely a stretch of lean years, such as farmers have had to go through before. It was a financial catastrophe, the full effect of which can not yet be measured. Though all parts of the country have not felt this depression equally, no region has escaped. Some regions may yet have to experience its full force. A large proportion of the most efficient and energetic producers occupying the best lands of the country have been hard hit through no fault of their own.
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> So extreme and one-sided was the drop in prices that the farmers were unable to believe it could last. This mistake, in which they were often confirmed by business men and bankers, aggravated the trouble. Farmers held on and in many cases borrowed to pay interest and taxes and to meet current expenses. As the depression continued the load of debt increased. Many farmers became discouraged and turned over their property to creditors. * * * An especially burdensome feature of the depression period was the fact that farm costs of production advanced while farm prices were declining. * * * Three years of big crops did little to pull them out of their troubles. In fact, efficiency in farm production seemed to make matters worse. In 1922 the spread between the prices of farm products and the prices of factory goods widened. While industry was booming, agriculture sank to lower and lower levels of depression (*76*).

Some of the factors which contributed to the farmer's difficulties and persisted throughout this period were overproduction of some crops and classes of livestock, farm prices below the cost of production, high wages of labor, excessive local and State taxes, high rates of interest in some regions, high freight rates, high cost of distributing farm products, economic depression and depreciated currencies in Europe, and high prices for services and articles which farmers and their families had to buy.

There was a large movement of population from the farms, caused in part by loss of property through foreclosures or otherwise and in part by attractive wages in other industries. On the whole, this movement was helpful to agriculture under the existing situation, but it created more or less unrest in rural communities, especially among the younger people.

The great urgency of the economic problems of agriculture and the widespread and insistent demands for Federal aid in solving

these problems brought the Department's work in this field to the fore and led to its very great expansion. The time and energy of the chief administrative officers of the Department and its corps of workers trained in agricultural economics were devoted to planning and executing research, regulatory, and extension work calculated to shed light on the actual condition and needs of agriculture at this time and to supply all available information tending to alleviate or remedy the farmers' difficulties. As always happens in such situations, many radical and impractical proposals for Governmental assistance were made, and some of these secured wide support in more or less influential circles. The Department therefore was under unusual obligation to study such proposals carefully and impartially with a view to taking advantage of any merits they might have and to combating their unsound features. The effort to make his Department as helpful as possible in this crisis, to guide its activities in useful paths, and to safeguard it against unwise and unreasonable demands, imposed a tremendous burden on the Secretary of Agriculture, which undoubtedly contributed to his untimely death.

The President and his Cabinet and both Houses of the Congress gave much attention to the consideration and enactment of measures for agricultural relief. In 1921 a joint Commission of Agricultural Inquiry, composed of Members of the Senate and House of Representatives, made a long study of the agricultural situation and issued a comprehensive report.

In January 1922 a national agricultural conference, called by the President, was held at Washington. It included 336 delegates, of whom 87 from 37 States represented some 20 national farm organizations, 80 were individual farmers from 30 States, 84 were officially connected with State agricultural organizations, 67 represented businesses having direct relation to agriculture, and 18 were women. This conference studied the agricultural situation broadly and made an elaborate report, containing many useful suggestions, some of which were later embodied in legislation.

Meanwhile the Congress had begun the consideration and passage of a series of acts intended to aid the farmers, which directly or indirectly affected the Department's work. Changes in the tariff, made in 1921, gave increased protection to agricultural products. The War Finance Corporation was enabled to provide large sums for agricultural needs. An amendment to the Federal Reserve Act gave agriculture representation on the Federal Reserve Board and made provision for handling agricultural paper for a longer time and for increasing the amount which might be loaned on individual farm mortgages. The agricultural credit act of 1923 provided 12 intermediate credit banks, through which large sums were loaned to farmers at reasonable rates of interest. The Capper-Volstead Act of February 18, 1922, encouraged the organization of farmers' cooperative associations by giving them good standing under the law.

Under the Agricultural Appropriation Act of March 3, 1921, the Department made seed-grain loans to 13,935 farmers in Idaho, Montana, North Dakota, and Washington, and this was repeated under the act of March 20, 1922, under which 11,968 loans were made in Montana, North Dakota, South Dakota, and Washington.

In the Future Trading Act of August 24, 1921, an attempt was made to establish Federal supervision and control of the exchanges

dealing in agricultural products by using prohibitive taxes to restrict their operation, but the United States Supreme Court declared this act unconstitutional. Congress then passed the Grain Futures Act of September 21, 1922, which authorized the Secretary of Agriculture to investigate grain-marketing conditions including the operation of boards of trade and to publish the results, and forbade the boards to attempt to manipulate the markets.

The Packers and Stockyards Act of August 15, 1921, gave the Department supervision over interstate packers, public stockyards, livestock commission merchants, and other market agencies, and put a stop to many improper practices in the marketing of livestock.

The Federal Road Aid Act of November 9, 1921, was a broad measure promoting the construction of a Nation-wide system of improved highways through cooperation of the Federal and State governments and opened the way for the expenditure of many millions of dollars of Federal and State funds for this purpose. Agriculture has shared to a considerable extent in the benefits of this act.

The inspection of fruits and vegetables, which had been made at terminal markets in different parts of the country, was expanded by authority of Congress given in 1922, to include many shipping points.

The Warehouse Act, which had applied only to cotton, grain, wool, and tobacco, was amended February 23, 1923, so as to include any agricultural product which might be considered properly storable under the provisions of the act.

The Naval Stores Act of March 3, 1923, gave authority to the Department for the inspection, grading, and branding of rosin and turpentine in interstate and foreign commerce.

The Cotton Standards Act of March 4, 1923, required the use of the official standards of the United States in interstate and foreign commerce.

The Purnell Act of February 24, 1925, gave additional Federal funds for State agricultural experiment stations and encouraged their broader use for investigations in rural economics and sociology and home economics. (For the history of this act see p. 275.)

CHANGES IN ORGANIZATION

The policy of segregating research, regulatory, and extension work within the several bureaus was continued. But since these lines of work ran side by side through practically all the bureaus it was desirable to have in the Department general officers who would promote the interests of the respective lines and aid the Secretary in their general administration. A beginning was made in this direction by the creation in 1921 of the office of Director of Scientific Work, and the appointment to that position of E. D. Ball, who had been Assistant Secretary of Agriculture (p. 213). The office of Director of Regulatory Work was then created but was not filled until Walter G. Campbell, of the Bureau of Chemistry, was transferred to that position in 1923. When the Extension Service was created July 1, 1923, C. W. Warburton, of the Bureau of Plant Industry, was made Director of that Service. Large interest in the work of the Dairy Division led to its promotion to the status of a separate bureau, beginning July 1, 1924.

In the States Relations Service the two offices of extension work were combined October 1, 1921, with C. B. Smith as Chief. That Service came to an end June 30, 1923. The Office of Experiment Stations, with E. W. Allen as Chief, was attached to the office of the Director of Scientific Work. The Office of Home Economics became a separate bureau, with Louise Stanley, formerly head of the home economics department of the University of Missouri, as Chief. The Office of Extension Work became the Office of Cooperative Extension Work, as a part of the Extension Service, which also included the Office of Exhibits and the Motion Picture Laboratory. The Bureaus of Markets and Crop Estimates were united in July 1921 and were combined with the Office of Farm Management and Farm Economics to form the Bureau of Agricultural Economics on July 1, 1922, with H. C. Taylor as Chief.

After the passage of the Packers and Stockyards Act and the Grain Futures Act, regulatory offices entitled "Administrations" were created to deal with the Department's business under these acts, respectively. Chester Morrill, as assistant to the Secretary of Agriculture, was put in charge of both of these organizations. Charles A. Browne returned to the Bureau of Chemistry as its Chief, on October 1, 1923.

On June 30, 1925, the number of Department employees was approximately 20,500, of whom 4,800 were in Washington, D. C.

REGULATORY WORK

The regulatory work of the Department grew in extent and importance between 1921 and 1925, and at the end of this period involved activities under more than 30 laws. This necessitated a very large amount of legal work in the office of the Solicitor of the Department, in addition to the services rendered in the bureaus and other divisions charged with the administration of these laws.

SERVICE WORK

After the war, while certain special services were abandoned, the scope and extent of the service work of the Department continued to grow.

The Weather Bureau further developed its weather forecasts and warnings and distributed them more widely with the aid of radio broadcasting. The Bureau of Animal Industry continued to accredit herds as free from tuberculosis and extended its cooperation with State agencies in the campaigns for eradication of cattle ticks and hog cholera. The Bureau of Plant Industry continued seed testing and distribution, the allotment of funds to farmers for purchases of seed, and the conduct of demonstrations on the reclamation projects. The Forest Service aided the larger use of the national forests for recreation. The Bureau of Chemistry continued its work for other Federal departments in testing supplies furnished on contract and in relation to specifications for the purchase of many articles. The Bureau of Entomology continued to aid the States in the determination of the spread of such insects as the gypsy moth, brown-tail moth, Japanese beetle, and boll weevil. The Bureau of Biological Survey participated more widely in campaigns for the destruction of

predatory animals. The Bureau of Soils steadily prosecuted its work on the national soil survey. The Bureau of Public Roads did much service work to aid the States in the development of highways under the Federal Highway Act, distributed surplus war explosives (picric acid) for clearing land, and aided communities in organizing irrigation and drainage districts. The divisions finally combined in the Bureau of Agricultural Economics, further expanded the estimating and other statistical work relating to crops and livestock, developed the market news service, and undertook the management of the Center Market at Washington, D. C.

EXTENSION WORK

The extension work conducted by the Department in cooperation with the State agricultural colleges under the Smith-Lever Extension Act went on steadily between 1921 and 1925 but without any large growth. The formation of the Extension Service in the Department in 1923 brought about a more complete coordination of the extension work of the bureaus with the cooperative extension work.

PUBLICATIONS

During this period the Department issued annually from about 400 to 500 new publications and 600 reprints and distributed about 30,000,000 copies, of which about 12,000,000 were farmers' bulletins. There was also a large amount of mimeographed material. The annual appropriation for printing and binding increased to $760,000. A single weekly periodical, entitled "Weather, Crops, and Markets", took the place of the Market Reporter, Crop Reporter, and National Weather and Crop Bulletin. An Official Record, issued weekly, gave information to members of the Department concerning its progress in different lines, its publications, etc.

The Motion Picture Laboratory increased the number of its reels to 1,862 copies of more than 200 different pictures by June 30, 1925, and the audiences to which Department films were shown during that fiscal year were estimated to have aggregated 9,000,000 people in all parts of the country.

The broadcasting of weather forecasts and market reports by radio began in 1921, and this service was rapidly extended. By 1925 several hundred radio stations were getting daily information from the Department on the weather, crops, markets, and other agricultural news. It was then estimated that over 550,000 radio sets were in use on farms.

LIBRARY

By July 1, 1925, the number of books and pamphlets in the Department Library had increased to 180,290, and the number of periodicals currently received increased to 3,314.

FUNDS

During the fiscal year 1925 the expenditures for the regular work of the Department aggregated $43,908,613. Of this amount, approximately $10,000,000 was used for research, $2,400,000 for extension work, $8,600,000 for the eradication or control of plant and animal diseases, insects, and other pests, $9,500,000 for the administration of

regulatory laws, and $13,300,000 for service work. In addition, $120,-500,000 was administered by the Department outside of its regular work, of which $107,500,000 was for Federal aid to the States for highway construction and for forest roads and trails, $1,440,000 for State agricultural experiment stations under the Hatch and Adams Acts, $5,880,000 for cooperative extension work under the Smith-Lever Act, $4,500,000 (of receipts derived from business on national forests and funds contributed by Forest Service cooperators) used principally for local road and school purposes, and $1,200,000 for forest conservation under the Weeks Act.

WEATHER BUREAU

The Weather Bureau broadened its study of meteorological conditions by obtaining daily observations made in Canada, Europe, Japan, China, West Indies, Central America, and the outlying possessions of the United States. It also studied ocean meteorology in cooperation with shipmasters and took part in an international study of the dust content of the atmosphere. Air-mail flight records for a year were analyzed in connection with the kite and balloon data. The relation between the anemometer-cup movement and the actual wind velocity was studied. Mathematical studies of the relation between weather and crops were continued. Radio broadcasting of weather reports and warnings was greatly expanded. On February 15, 1923, broadcasting three times daily from the powerful Government station at Arlington, Va., was begun.

BUREAU OF ANIMAL INDUSTRY

The Bureau of Animal Industry continued investigations relating to hog cholera and gave special attention to the immunization of suckling pigs by the simultaneous method.

Much bacteriological work on the so-called "hog flu" failed to discover the causative agent. It was shown, however, that the disease is distinct from hog cholera and is transmitted by contact.

Investigations on hemorrhagic septicemia of cattle resulted in the discovery of a very effective agent known as aggressin, which produces rapid and durable immunization.

Carbon tetrachloride, proposed by the Zoological Division of this Bureau in 1921 as an anthelmintic for the removal of hookworms, has proved so effective that it is now in world-wide use in human and veterinary medicine.

The mode of action of disinfectants, including soaps, phenols, and alcohols, was studied. Bacteriological work with the primary alcohols from methyl to octyl inclusive was completed.

Investigations on infectious abortion, tuberculosis, roundworms in sheep and hogs, and poisonous plants were continued.

Inbreeding work was done with guinea pigs, swine, and poultry. Poultry breeding experiments at the Beltsville farm dealt with improvement in egg production and maintenance of typical breed character and standard quality. Different systems of mating were studied.

The vitamin content of the muscle tissue of beef, pork, and mutton, and of the meat and eggs of poultry was extensively studied. There

were also investigations on the effect of the vitamin content of the diet of hens upon the yield, fertility, hatchability, and vitamin content of the eggs.

Much progress was made in chemical studies of the nutritive values of proteins in the tissues of cattle, sheep, and hogs. Work on the composition, nutritive value, and wholesomeness of edible viscera from meat food animals was continued.

Feeding experiments with cattle, hogs, and sheep on farms and ranges in different parts of the country were continued, largely in cooperation with the State experiment stations. Among these were experiments on cut-over pinelands in Mississippi. A 5-year study of methods and cost of fattening cattle in the North Central States, involving 100,000 animals, was completed.

Experiments in search of the causes of the production of soft pork in the South were continued with many kinds of feedstuffs.

The transfer in April 1924 of the Fort Keogh Military Reservation in Montana to the Bureau enabled it to begin breeding and feeding work under range conditions on a much larger scale. This tract, now known as the United States Range Livestock Experiment Station, contains 57,000 acres, 2,000 of which are under irrigation, thus making possible the production of feed and forage to supplement the range grasses. Horse breeding at Middlebury, Vt., and Laramie, Wyo., was continued.

Dairy research was considerably increased during this period. It included studies in the chemistry and bacteriology of milk and the relations of such investigations to the manufacture of ice cream, condensed milk, and cheese, and to the utilization of skim milk, buttermilk, and whey.

Various kinds of experiments on the management and feeding of dairy cattle were conducted at the Bureau's farm at Beltsville, Md., until the Bureau of Dairy Industry was formed. Among other experiments were those on the effect of different feeds, including cactus, linseed meal, and cottonseed meal, on the percentage of fat in milk. Dairy-cattle breeding experiments were carried on with five herds owned by the Bureau and also in cooperation with a number of State experiment stations.

BUREAU OF PLANT INDUSTRY

The Bureau of Plant Industry was operated during the fiscal years 1922 to 1925 on the same general plan of organization and lines of work as in previous years. Expansion of its operations resulted from increase of its appropriation from $3,147,770 in 1922 to $3,839,405 in 1925. The annual expenditure for experimentation and research rose in this period from about $2,500,000 to a little over $3,000,000. The Bureau's work was divided among about 325 projects, most of which involved research. Fully 60 percent of the research was carried on at field stations, and much of it was done in cooperation with the State experiment stations.

Work with cotton included physiological studies on the development of branches, buds, flowers, and bolls; on the pollination of different types; and on the factors connected with the resistance of Egyptian and upland varieties to alkali and drought. With market demands in mind, the breeding work was confined to production of

varieties having staple one inch or more long. Improved varieties and methods of culture extended the northern limit of cotton growing, particularly in the dry sections of New Mexico, Oklahoma, and Texas. Studies on the effect of mixing different varieties in the ginning led to greater emphasis on the importance of confining production to one variety in each community. Experiments showed the advantage, in dealing with the boll weevil, of agreement among farmers in a community to plant on a specified date, which need not be particularly early or late.

Methods of breeding corn received increased attention. New varieties from Bolivia, Peru, and Chile were brought in, and some strains and varieties from high altitudes in the Andes were found to grow well in this country at relatively low temperatures.

Strains of wheat immune or highly resistant to bunt, flag smut, and rosette were developed. Varieties were introduced from north Africa, India, and Spain. Cultural methods, effect of size of seed, and electrochemical treatment of seed wheat were tested.

Alfalfa seed from South America was tested in the field and in greenhouses in different parts of the United States. Studies of yellowing of alfalfa and other legumes were made.

Among the new grasses proving valuable for the Southeast were molasses grass, Dallis grass (*Paspalum dilatatum*), Bahia grass (*Paspalum notatum*), and Vasey grass (*Paspalum larranagai*). In the Northwest, crested wheatgrass (*Agropyron cristatum*) was found to be hardy, drought-resistant, and palatable. It was shown that Huron timothy, developed in Ohio, remains green long after seed matures. Korean lespedeza proved useful in the Corn Belt.

Among the large numbers of vetches tested, the woolly-podded vetch showed superior value for the South, the purple vetch gave good results in California and Oregon, and the Hungarian vetch (*Vicia pannonica*) promised to be of much value on wet clayey soils in the Pacific Northwest.

Studies of potato sterility, made in cooperation with the New York Botanic Garden, showed that the chief causes were premature abscission of the buds or blossoms and imperfect pollen. Tests of varieties for immunity to wart indicated that in general the immune varieties and those susceptible are in distinct horticultural groups. Studies on the heredity of immunity to wart showed it to be a dominant character and not linked with undesirable characters.

Experiments with a number of fertilizers and with sulphur in several soil types showed that potato scab can be controlled by using fertilizers which have a tendency to make the soil acid. Experiments with overgrown tubers for seed showed that the number of eyes on pieces from such tubers was smaller than that on pieces of the same size from smaller tubers. Tests of different methods of storing potatoes in Aroostook County, Maine, favored the use of ventilated bins.

Cropping tests with tobacco showed that this crop is not especially destructive of soil fertility, but that the system of cropping is mainly responsible for soil exhaustion. Much depends on the type of rotation, but no system of rotation equalled the old plan of resting the land for a period of several years.

Tests of varieties and breeding and selection work with sweetpotatoes were continued. Since sweetpotato seed will not ripen in

the latitude of Washington, D. C., seed of a number of important varieties was obtained from the Virgin Islands for the production of seedlings.

Breeding of sugar beets and experiments with field practices were conducted in cooperation with the Michigan Agricultural College. Studies of the storage of mother beets at Salt Lake City, Utah, led to improved methods of selection. Fertilizer experiments in the Arkansas Valley showed that phosphoric acid was important in preventing decreased yields of sugar.

With peas, tests of seeds of the Alaskan variety with reference to their use for canning showed many not true to type. This causes much loss to growers and canners. Over 400 varieties and strains of peas were planted at McMillan, Mich., in 1924.

Studies of blackheart of celery conducted at Sanford, Fla., showed this disease to be influenced more by fluctuations in the water supply than by the fertilizers.

Root-cutting propagation of apples was shown to have distinct limitations and to be commercially impracticable. The rate of softening of a number of varieties in storage at from 32° to 83° F. was determined. Varieties slow in softening at about 40° are ideal for holding in common storage.

Various methods of preserving surplus peaches in dry sugar and sirup in wooden barrels and tin cans were tested. Peaches thus stored were found to be very satisfactory for use in making ice cream.

Citrus-fruit breeding was continued, and several new hybrids were brought into use. Eustis limequat was added to the list of commercial varieties. Citrangequat was found useful as stock for Satsuma oranges. The propagation of Rusk citrange cuttings to be used as stocks for the Satsuma orange reached the stage of field demonstration. Progress was made in the use of wild Australian relatives of citrus as stocks. The importance of careful bud selection in the propagation of citrus trees was confirmed by further experiments and by the practice of growers. Additional Satsuma varieties were introduced from Japan. Experiments showed that severe pruning of orange trees in California is unnecessary. The rate of cooling of oranges on trees as related to air temperatures was determined in southern California. The furrow-manure method of applying fertilizers to citrus trees in California was found efficient and economical. The conditioning of citrus fruits by confining them in airtight compartments and exposing them to the products of incomplete combustion of kerosene or gasoline passed into commercial use.

The Saidy variety of dates from Egypt was introduced on a large scale for use in the Imperial Valley of California. Pollination studies showed marked differences in the viability of pollen.

Varieties of avocados were introduced from mountain regions in Ecuador. The Collinson variety was found to be devoid of pollen but desirable for planting in association with other varieties. Different varieties showed a wide range of resistance to cold. Considerable attention was given to breeding new varieties.

Breeding of strawberries, raspberries, blackberries, and blueberries was continued. Several forms of *Fragaria chiloensis* were introduced from Ecuador and Chile. Experiments in spraying for leaf

diseases of strawberries in North Carolina indicated that usually it is better to use less susceptible varieties and renew the beds frequently. Experiments on the fertilizing, handling, storage, and shipment of strawberries, raspberries, and blackberries were made in the Pacific Northwest.

A field station was established on 50 acres at Philema, Lee County, Ga., for experiments with pecans, and an adjacent seedling grove was put at the disposal of the Bureau for experiments in top-working pecan trees. Tests to determine the relative value of budding and grafting were begun. Experiments in crossing and with fertilizers and cover crops were undertaken at this station. A collection of trees of different varieties from nurseries in six States was planted. Soil conditions and fertilizer requirements for pecans were investigated in Alabama, Florida, and Georgia. Storage experiments were made with pecans, Persian (English) walnuts, almonds, and filberts. The blooming habits of several varieties of Persian walnuts were studied. The growing of Persian varieties of pistache was promoted in the Southwest. Breeding of almonds was undertaken in California.

In the study of rubber plants an expedition was sent to the Amazon Valley to get data on production and methods of extraction of the latex. Observations were made on the plantings of rubber trees in Haiti and Nicaragua. An investigation of the different species of rubber plants growing in the Southwestern States was made. Various kinds of rubber plants were grown at the United States Plant Introduction Garden at Miami, Fla., desert types were grown in California, and tropical kinds in the Canal Zone. The diseases of the Hevea rubber tree were studied in Guiana and Trinidad.

Breeding experiments with roses and chrysanthemums were continued. The production of iris, hyacinths, tulips, Easter lilies, and narcissuses in the United States was promoted. Studies were made on the color of the early foliage and the duration of flowering of peonies.

Work with drug plants included experiments with insect powder flowers, menthol plant (*Mentha arvensis*), Levant wormseed, safflower, Manchurian hemp, rose geranium, lemon grass, and various oil plants. Experiments with several species yielding chaulmoogra oil were made in the Canal Zone, Puerto Rico, and other tropical American countries.

The permeability of the soil to water as influenced by its dissolved salts and the effect of the application of small quantities of calcium sulphate or aluminum sulphate on permeability were studied.

The comparative effects of different crops on the yields of other crops following in the rotation and of intermittent and continuous food supply for plants were studied. The beneficial effect of legumes in the rotation was found to be due chiefly to their effect on the microflora of the soil.

Investigation of new problems of mixing, conditioning, and distribution created by introduction of concentrated fertilizer salts on the market were undertaken.

Further experiments under controlled conditions were made on response of plants to both natural and artificial light. Field studies were made under practical growing conditions of the significance of

length of day in controlling the time of flowering and fruiting of certain types of plants and their adaptability to different latitudes.

Dry-land investigations in the Great Plains made substantial progress between 1921 and 1925, and some definite conclusions were reached as to the conditions under which homes may be established in this region.

In investigations on plant diseases increased attention was given to controlling disease by growing varieties of plants immune or more or less resistant to the diseases. The range of different diseases and the regional or local conditions affecting their development, spread, and control were also studied.

Take-all of wheat and similar diseases were found to be widespread. Much attention was given to the causal fungus (*Ophiobolus graminis*) of true take-all and the conditions under which it attacks the wheat plant at different stages of growth. Wheat rosette was shown to be caused by a virus capable of existing for a long period in certain soils and its characteristic effects on wheat plants were determined. Studies of the development of scab on wheat and of the nature of the causal fungus were made.

Continued study of crown rust of oats and related wild grasses showed that all species may produce aecia under climatic conditions.

The relation of various bacteria and fungi to root, stalk, and ear rots of corn was determined. A distinct bacterial disease of corn similar to bacterial wilt was discovered in Illinois.

A distinct type of degeneration disease of potatoes, named spindling tuber, was discovered which, like mosaic and leaf roll, is transmitted by seed tubers and from plant to plant by aphids. Further studies of mosaic showed three distinct types.

Sugarcane mosaic was found on seven new wild hosts in 1924. Work on the root disease of sugarcane disclosed that the predisposing cause is the attack of an extremely small subterranean snail.

Curly top of sugar beets was found to be transmitted by the beet leafhopper (*Eutettix tenella*), but when transmitted to certain wild plants it is modified and becomes less virulent when transmitted from these plants to beets.

Results of field studies of brown root rot of tobacco in the Connecticut Valley indicates that the disease is not parasitic but is due to chemical properties of certain soils.

Experiments showed that the attacked stems ("buttons") of citrus fruits potentially infected with stem rot may be effectively removed by employing an adaptation of the gassing treatment used to hasten the coloring of the fruit and that this treatment will prevent decay of the fruit. Tests of ultra-violet light for the surface disinfection of citrus fruits to control blue mold rot showed that while most of the spores could thus be quickly destroyed the remainder might later cause infection. A saturated solution of borax applied to the surface of the fruit not only protected it against blue mold rot but also reduced stem-end rot.

Investigations of cranberry diseases in Massachusetts showed that flooding to destroy insects favors infection of the vines and fruit by fungus diseases. The life histories of the fungi causing end rot and black spot of cranberries were worked out.

Cucumber mosaic, transmitted by wild cucumber, milkweed, pokeweed, and ground cherry, was successfully controlled in Illinois and

Wisconsin by destroying these wild hosts. Cabbage blackleg was successfully controlled by a special method of hot-water treatment of the cabbage seed. Pea root rot was found to be caused by a soil infection which increases from year to year. Investigation of the brown blight of lettuce in the Imperial Valley of California verified the previous conclusion that this disease is partly or wholly soil borne.

White-pine blister rust was discovered in 1921 in southwestern British Columbia and the Puget Sound section of Washington. Prompt action was taken by the Bureau of Plant Industry, in cooperation with State and Canadian authorities, to determine the extent of the infected area, and if possible to control or eradicate the disease. It was found that all of the 16 northwestern species of *Ribes* tested were susceptible to the disease. However, field evidence showed that the eradication of black currants would greatly retard its spread, and a campaign for this purpose was vigorously prosecuted. Quarantines were also established.

Study of the causes and control of decay of lumber and other wood products was carried on in cooperation with the Forest Products Laboratory of the Forest Service, with special attention to Douglas fir in Oregon and Washington. Studies of the western hemlock, silver fir, Sitka spruce, red cedar, and Douglas fir, blown down by a hurricane on the west coast of Washington in 1921, showed no decay after 4 years, but fallen western yellow pine decayed rapidly.

Nematode studies showed that the species which infests certain bulbs and the stems of clover, alfalfa, and strawberries was increasing in the Northwest. Wild hosts were also found in both the West and the East. Two nemas, classed as mermithids, were discvored infesting grasshoppers, particularly the red-legged locust and its relatives and the clear-winged locust of the Northwest.

FOREST SERVICE

The Forest Service continued experiments and researches on the general plan previously described. The number of field stations was gradually increased. In 1925 work on forest problems was conducted through six stations, with headquarters as follows: Southern, New Orleans, La.; Appalachian, Asheville, N. C.; Northeastern, Amherst, Mass.; Lake States, St. Paul, Minn.; North Rocky Mountains, Missoula, Mont.; and Pacific Northwest, Portland, Oreg. There were also small stations at Colorado Springs, Colo., and Flagstaff, Ariz. The work pursued at these stations included such general subjects as methods of cutting, growth, and yield of timber, losses from forest fires, methods of fire protection, effects of grazing on natural forest reproduction, and experiments on reforestation. Special investigations were conducted in the South on methods of turpentining and the growth of southern pines, and in the West on the relation of forest fires and weather on the natural reproduction of western yellow pine and Douglas fir.

Among the investigations at the Forest Products Laboratory were those on the standardization of grades and the uses of softwood yard and factory lumber, and hardwood lumber, the dimension-stock requirements of various secondary wood-using industries (e. g., automobiles, chairs, and furniture in general), the best actual thickness for so-called 1-inch boards, preliminary kiln-drying to prevent deteriora-

tion of lumber, uses of mill waste and sawdust, wood preservatives for use in house construction and on farms, painting characteristics of various woods, and shipping containers of various kinds.

Pulp- and paper-making investigations were continued, and included studies of the chemistry of cellulose with reference to increase of yield under pulp processes, an improved method of analyzing cooking liquor in making sulphite pulp, experiments with about 90 little-used species with reference to their availability for pulp, the use of southern pine for high-grade white paper and of jack pine in the Lake States for container board, effects of decay on pulpwood and pulp, and methods of reducing decay during hauling and storing.

More attention was given to economic studies, including forest taxation, trend of prices of standing timber and sawed lumber, lumber transportation, economic consequences of forest fires and forest-land devastation, and effect of "timber mining" as compared with timber growing. An extensive compilation of the forest resources of the world was completed.

Continued investigations were made on the problems of range management, largely at the Great Basin Experiment Station in Utah and at the Jornada and Santa Rita range reserves in New Mexico and Arizona. Among the important results of range investigations up to 1923 were the following: (1) Systems of range management, especially deferred and rotation grazing, which maintain the forage resource and increase its carrying capacity, were developed; (2) the improvement of ranges by artificial reseeding was made possible under favorable conditions; (3) too early grazing was prevented by determining the proper seasons for grazing various types of forage; (4) the open herding and bedding-out system of handling sheep was applied on over 65 percent of the national-forest ranges and on many private holdings, with a resultant increase of from 15 to 20 percent in the carrying capacity of the ranges; (5) practical methods for eradicating tall larkspur, waterhemlock, deathcamas, and other poisonous plants were developed; (6) practical and efficient ways of developing water under the varying conditions of the Southwest were worked out; (7) a practical and efficient system of cattle management on the semidesert ranges of the Southwest which permitted satisfactory production and helped to prevent excessive losses during drought was developed.

The 10-year study of the effect of grazing on the erosion of alpine lands at the Great Basin Experiment Station in Utah demonstrated that revegetation of the range reduced the run-off and erosion by approximately 66 percent. Studies of grazing management on the browse ranges in the Southwest and on the logged-over lands in the Northwest were expanded. After 4 years' work on the browse ranges in southern Utah it was found that the basis of stocking should be proper utilization of the herbaceous and more palatable browse vegetation, with incidental grazing of the less palatable species.

FIXED-NITROGEN RESEARCH LABORATORY

The Fixed-Nitrogen Research Laboratory was established by the Secretary of War, March 29, 1919, to continue researches on nitrogen fixation begun during the World War. Authority for this work was contained in the National Defense Act of June 3, 1916, in which the

President was authorized to cause investigations to be made "to determine the best, cheapest and most available means for the production of nitrates and other products for munitions of war, and useful in the manufacture of fertilizers and other products." The work was done at a laboratory on the grounds of American University, Washington, D. C. On July 1, 1921, the laboratory was transferred by Executive Order to the Department of Agriculture. The early work of the laboratory bore on the utilization of the cyanamide plant at Muscle Shoals, Ala., and the nitrate plant at Sheffield, Ala., designed to operate by the direct synthetic (Haber) process for nitrogen fixation. Some research was also conducted on other methods of nitrogen fixation, and the transformation and utilization of nitrogen compounds.

As a branch of the Department of Agriculture the laboratory continued work on the synthetic ammonia process and the cyanamide process. It improved the ammonia catalyst and its method of manufacture and made studies of the factors which contribute to the activity and length of life of the catalyst, and especially to its resistance against deterioration caused by impurities in the gases. The extent of cyanide formation in blast furnaces and the feasibility of its recovery were investigated. The aluminum-alloy-nitride process for fixing nitrogen in the form of ammonia was studied. In cooperation with the Bureau of Plant Industry investigations were made on the utilization of calcium cyanamide as a fertilizer, as well as on processes for producing urea and urea-containing mixtures from calcium cyanamide. Problems connected with the fixation of nitrogen by soil bacteria were studied. This work included a study of what the bacteria get from the plant in exchange for the nitrogen from the atmosphere and "whether or to what extent artificial culture media may be made to take the place of the root nodules as a soil for these bacteria."

Since the various forms of fixed nitrogen are not equally suited for use as fertilizers the problem of converting one form into another demanded attention. Under this head the synthesis of urea from carbon dioxide and ammonia was investigated.

BUREAU OF SOILS

The Bureau of Soils continued the soil survey. From the beginning of the survey to June 30, 1925, the total area covered in detail in the 48 States and Puerto Rico was 684,451 square miles, or 438,048,640 acres. Reconnoissances had covered 569,973 square miles in addition. The Bureau, in cooperation with the Department of Commerce, made a field study of soils in Colombia, Ecuador, Peru, Bolivia, Brazil, and all the Central American countries except Mexico; and in the Philippines, Borneo, Sumatra, the Malay States, and India. The special object of this work was to gather information on the relations between the soil and the growth of rubber trees, but many data were also collected on the fundamental characteristics of the soils in the regions visited. A study of the soils in Brazil suitable for cotton growing and in Argentina for corn and wheat production was also made. A study of soils in Cuba was made in cooperation with the Tropical Plant Research Foundation. Nearly 50 distinct soil types were recognized and defined on this island.

Continued chemical investigation of the colloid material in soils resulted in developing two different methods for determining the total quantity of such material, and it was found that colloids constitute a far larger part of the whole soil than previously had been thought, some of the heavier soils containing as much as 80 per cent. Considerable progress was also made in determining the properties of the colloids in different soils. A relation between the colloid content and the mineral content of the soil was discovered. A study was made on the effect of colloids on the movement of water through the soil and on other physical properties.

By modifying the process ordinarily used in the preparation of ammonium phosphate so as to include the use of commercial potassium chloride, as well as phosphoric acid and ammonia, it was found that a concentrated product containing all of the essential constituents of fertilizer may be obtained.

Continued efforts were made to reduce the cost of the processes in the production of potash from American sources such as greensand and byproducts from various industries. A study of organic ammoniates, principally trade wastes, e. g., cocoa press cake and animal wastes from small-scale slaughter, was made.

BUREAU OF CHEMISTRY

The study of vegetable proteins was continued by the Bureau of Chemistry. The percentages of tryptophane and cystine in a large number of proteins were determined.

In an investigation on the odorous constituents of the cotton plant one (trimethylamine) was found that had some attraction for the boll weevil.

A mixture of ethylacetate and carbon tetrachloride as a substitute for carbon disulphide as a fumigant for stored grain was found to be effective in killing weevils and was noninflammable, did not lower the germination of seeds, and did not injure the baking quality of flour milled from fumigated wheat.

Investigations in Louisiana resulted in an improved method of producing unsulphured cane sirup. A method of preventing crystallization of cane sirup by use of the enzyme invertase derived from yeast was devised. This method was extended to sorghum sirup, which did not crystallize even when concentrated to high density. There were also studies on the utilization of blackstrap molasses.

The composition of vegetable oils, including crude cottonseed oil, sunflower-seed oil, soybean oil, and chufa-tuber oil, was studied systematically.

Investigations relating to plant-dust explosions and fires were broadened to include threshing machines, grain elevators, grinding machinery, and cotton gins.

Studies on insecticides dealt with the physiological effect of arsenicals on insects, the quantity of poisonous elements on sprayed fruit and vegetables, the absorption of hydrocyanic acid by fumigated food products, and foliage injury by lead arsenate and other insecticides.

Experiments were made in waterproofing, mildewproofing and fireproofing various fabrics used on farms. Studies were made on the physical properties of papers used for wrapping fruits and vegeta-

bles, for preparing negatives from original drawings on tracing cloth. and for maps.

A chemical method of determining maturity in cantaloups was worked out and successfully applied in commercial practice.

In an investigation to develop methods for standardizing raisins, a test was worked out for determining the extent of mold injury, depending on the catalase activity of mold.

A monograph on the mold group *Aspergillus*, giving the results of 20 years of systematic studies, was completed. This covers the morphology and physiology of these molds, their biochemical activities, their use in industries as fermentation agents and as sources of enzymes, and their appearance and significance in human and animal disease. Studies in the bacteriology of fresh and canned vegetables and the means of preventing spoilage of canned goods were continued.

Investigations on repellents for use against the screw worm and other flies attacking animals on the ranges showed that small quantities of chloropicrin in mineral oil or in pine-tar oil were very effective in repelling flies, and that wounds treated with this mixture healed rapidly.

BUREAU OF ENTOMOLOGY

The Bureau of Entomology carried on its work between 1921 and 1925 on the same general plan and with the same kind of organization as in previous years. Field stations were maintained in different parts of the United States and much work was done in cooperation with the Bureaus of Chemistry and Plant Industry and the Forest Service, as well as with many State agricultural experiment stations, departments of agriculture, and other agencies.

An insect-pest survey was begun in March 1921. Through monthly bulletins it provided a permanent record of insect conditions in the United States and Canada, correlated with the prevailing meteorological conditions from year to year. Much scouting was done to determine the geographic distribution of certain important insects, such as the gypsy moth, brown-tail moth, Japanese beetle, European corn borer, Mexican bean weevil, and some forest insects.

Fundamental investigations were made on the physiology of insects and much attention was given to biological and ecological studies on a large number of insects of economic importance. The regional and seasonal life history of many insects was studied.

Investigations relating to insecticides included the determination of plants containing insecticidal properties and studies of miscible oils and their combination with various substances for insecticidal purposes. Improved machines for dusting were devised and the use of airplanes in spreading insecticides on a large scale for control of the cotton boll weevil, mosquitoes, and other insects was inaugurated and developed. Fumigation with hydrocyanic acid and other gases for control of insects in the field, in storage houses, and in greenhouses was further developed. The collection of parasites for various insects in Europe and other foreign countries and their introduction and observation in the United States were carried on more broadly.

As the European corn borer continued to spread westward the Bureau did what it could to stimulate and guide measures for its control.

Much seasonal and biological information regarding it was collected and the relative susceptibility of different varieties of corn to its attacks was studied. Particular attention was given to finding and testing parasites for this insect in Europe and to introducing promising species into infested areas in the United States.

In the continued work on the boll weevil emphasis was laid on the use of calcium arsenate for control of the pest. New types of dusting machines were devised. The feasibility of using airplanes for dusting considerable areas was demonstrated. Devices for distributing the poison from the planes were developed and the equipment of the planes was adapted to the purpose. Studies of calcium arsenate revealed different types of this insecticide and suggested modifications in its use to make it more effective and less expensive. Sweetened dry calcium arsenate mixtures and a variety of proprietary mixtures were compared in actual control practice. The effect of the measures taken for boll weevil control on the appearance of other cotton insects was studied.

Much attention was given to life history and ecological studies of the Japanese beetle, including those on the physiology of the insect in all its stages, with special reference to environmental conditions and methods of control by means of poison sprays and baits, fumigants, and parasites.

The Mexican bean beetle spread rapidly through the Southern States and as far north as Lake Erie. Its life history and habits in the different regions were studied and experiments with arsenical insecticides, repellents, ad parasites for its control were made.

In the work on the gypsy moth, intensive scouting and clean-up operations were carried on to establish a barrier some 20 miles wide from the Canadian border through Vermont, eastern New York, Massachusetts, and Connecticut to Long Island Sound. Search for parasites was actively prosecuted in Japan and in several European countries. Methods of shipping parasites were improved, biological studies on new introductions were carried on, breeding and colonization work was done on the parasites already successfully established, and papers dealing with their biology and morphology were prepared.

As part of the work with peaches, investigations on the plum curculio were carried on for several years in Georgia and included life-history studies and insecticide experiments. Spraying and dusting experiments with arsenicals were conducted, and in 1924 an airplane was used for the first time, giving results that compared favorably with those obtained with power dusters operating on the ground. The great value of picking up infested dropped fruits, especially during years when fruit is unusually abundant, was demonstrated. Paradichlorobenzene was tested as a means of controlling the peach borer in Georgia and Indiana, with special reference to the age of trees to which this chemical may safely be applied.

Use of oil emulsion for control of scale insects and white flies on citrus fruits in Florida received special attention. An outbreak in 1924 of an aphid (*Aphis spiraecola*) as a new enemy to the orange led to a study of its life history, habits, food plants, especially during the spring, and predacious enemies, and to experiments with various kinds of insecticides for its control.

From biological studies of the citrus thrips in California, it appeared that this insect does not overwinter in trash under trees but in the egg stage in the tenderest growth of the preceding fall.

Investigations relating to the Mediterranean fruit fly in Hawaii included studies on the amount of infestation in different fruits, the susceptibility of cooking bananas, Guatemala avocados, and papayas to attack by the insect, and the effects of cold-storage temperatures on the larvae. Investigations of fruit flies and other insect pests of bananas, avocados, mangoes, and other tropical fruits in the Canal Zone were conducted during this period.

Much attention was given during this period to finding safe and efficient fumigants for protection of stored grains, beans and peas, cured meats, hides, and clothes from insect attack. Passage of the Grain Standardization Act led to increased effort to find a safer fumigant than carbon bisulphide for stored grain and like products.

Control of the western bark beetle was the subject of large-scale projects in a number of national forests and on smaller areas, and of biological studies.

Problems relating to the biology and control of malaria mosquitoes (*Anophelas*) continued to be studied. A 3-year investigation, including clinical and biological features, was completed in cooperation with the International Health Board. Field studies at Mound, La., on the biology, distribution, and seasonal behavior of *Anopheles* mosquitoes were continued, and a report on types of breeding places in this locality and the natural conditions affecting mosquito breeding was published. Tests were successfully made to determine the feasibility of distributing larvicides over large areas by means of airplanes. In cooperation with the School of Hygiene of Johns Hopkins University, studies of the host preferences of *Anopheles* were made.

Investigations in the control of the screwworm attacking livestock were continued in Texas, and included tests of different types of traps, bait pans, baits, larvicides, and repellents of different materials.

At the bee-culture laboratory and experimental apiary at Somerset, Md., investigations of the responses of colony activity to changes in external temperature, humidity, light, and other factors, and of the quality of the honey produced were conducted from 1921 to 1925. A study of the colors of American honeys from all parts of the country led to the perfecting of a honey-color grader. The relation of fungi to honeybees was investigated, special attention being given to species of *Aspergillus*.

BUREAU OF BIOLOGICAL SURVEY

The work of the Bureau of Biological Survey from 1921 to 1925 was carried on through seven divisions assigned as follows to: (1) Economic investigations, (2) fur resources (established July 1, 1924), (3) food-habits research, (4) biological investigations, (5) Alaskan wildlife, (6) game and bird refuges, and (7) protection of migratory birds. The service and regulatory work of this Bureau was greatly increased and in connection with these lines of work a large amount of information on the life history, habits, distribution, migrations, and economic relations of birds and animals was obtained and re-

corded. In 1924 the files of the Bureau contained 1,500,000 cards in addition to a great mass of original manuscripts on the birds, mammals, reptiles, and amphibians of North America.

In connection with the extensive campaigns for the control and eradication of injurious animals in the Western States, laboratory and field studies of poisons and their preparation and use in destroying predatory animals and rodents were made. The relation of rodents to forests and reforestation was studied in the yellow pine section in northern Arizona. Experiments and investigations on the rearing, mating, gestation, whelping, feeding, housing, and management of fur-bearing animals were made at the experimental farm at Keeseville, N. Y. (transferred to Saratoga, N. Y., in 1924) and through field observations in Alaska and Canada. Special attention was given to red, cross, blue, and silver foxes, but some work was done on martens, skunks, and a few other animals. Studies were also made on the internal and external parasites of foxes, agents for their removal, and methods of administering remedies.

Studies of the food habits of birds, toads, and some mammals were continued, involving the examination of the contents of many stomachs of English sparrows, shore birds, fish-eating birds, hawks, owls, pigeons in California, toads (of 29 species), prairie dogs, jack rabbits, etc. The biological survey was continued, and monographs recording the results in several States were prepared.

With the aid of funds contributed by property owners in the district between Thomasville, Ga., and Tallahassee, Fla., an investigation of the life history of the quail and all factors affecting the abundance of the species was undertaken. The rapid growth of the reindeer industry in Alaska inspired an investigation of the plants on which the animals feed and of the carrying capacity of the ranges. The condition of this industry in northern Europe was also studied.

BUREAU OF PUBLIC ROADS

The Bureau of Public Roads made numerous investigations in road construction and maintenance. The resistance of highway surfaces of many different kinds to the impact of motortrucks was tested and measured. The stresses and deflections of concrete and specially constructed roads were determined under actual traffic conditions. Subgrade materials were classified on the basis of definitely determined characteristics, and methods of their examination, testing, and treatment were studied. The warping and movement of road surfaces through natural causes were investigated. Studies on the action and strength of skew arches on bridges were made. Surveys of road transportation, with special reference to busses and trucks, were made in several States. They covered the weight and number of vehicles, character of commodities, and length of haul. Much attention was given to methods of investigating different problems and to designing and constructing machines and apparatus for experimental work. Economic researches included those on highway planning and financing, the effect of highway improvement on land values, and the field and scope of motor-truck transportation.

In irrigation the water requirements of different crops were investigated. Field studies on the water-holding capacity of different soils and the effect of drains at different depths were made. Evap-

oration losses were determined in the hydraulic laboratory at Fort Collins, Colo., and at East Park reservoir in California, as well as from relatively saturated soils. The principles involved in designing and constructing earthen dams and embankments were studied. The seepage losses in canals and through earthen dams, the sedimentation in canals, and the drainage run-off from irrigated lands in several States were determined. The cost of farming irrigated land and the cost of water to irrigators were investigated, as well as the laws relating to irrigation and drainage districts. Drainage studies were continued on the run-off from lands in different States, the effect of alkali on concrete tiles, the discharging capacity of culverts, the depth and spacing of tile drains, soil erosion, and sedimentation.

Investigations in agricultural engineering covered ventilation of barns and other farm buildings, power on the farm, the use of tractors, and methods of distributing concentrated fertilizers.

In cooperation with the Bureau of Entomology, studies were made on the design, construction, and testing of dusting apparatus to be installed in airplanes, and with the Bureau of Plant Industry on the icing of refrigerator cars for transportation of fruits and vegetables.

OFFICE OF EXPERIMENT STATIONS

The Office of Experiment Stations continued the management of the Federal experiment stations in Alaska, Hawaii, Puerto Rico, Guam, and the Virgin Islands. In Alaska the station at Sitka continued to pay special attention to experiments with hybrid strawberries and the breeding of potatoes. Of some 40 varieties of apples grown there in about 20 years, only 5 were retained in 1925 as worthy of further testing. The Matanuska Station was further developed. Varieties of wheat, oats, barley, alfalfa, grasses (especially *Bromus inermis*), and potatoes were successfully grown there. At the Fairbanks Station field experiments with grains and forage plants were continued. A small experiment in crossing yaks and Galloway cattle was undertaken. The work of the Rampart Station was reduced to the breeding of grain and forage plants for use at the Fairbanks and Matanuska Stations. Hardy varieties of wheat, alfalfa, and a garden pea were developed and established. At Kodiak the crossing of Galloway and Holstein-Friesian cattle for increased milk production by hardy animals was continued.

The Hawaii Station gave much attention to the vegetative propagation of tropical fruit trees. Variety tests and breeding experiments with numerous fruits, vegetables, and forage plants were continued. Pigeonpeas and pineapples were grown in rotation with sugarcane. Further work was done in promoting the establishment of the starch industry, based especially on the edible canna. Cooperative experiments were made in Hawaii and on the mainland with reference to a supposed deficiency of iron and other minerals in Hawaiian vegetables. Methods of manufacturing various fruit and vegetable products were studied, with special reference to the utilization of surpluses.

The Puerto Rico Station studied the relation of various soils to phosphatic fertilizers as influenced by the time the fertilizer was in the soil and by liming. It was found that certain nitrogenous fertilizers promoted chlorosis in rice and that nitrates were not so good

for young rice plants as ammonium salts. In experiments with fertilizers for sugarcane, nitrogen was the controlling factor. The effect on plant growth of variation in the length of daylight was studied. Uba sugarcane was found to be quite resistant to the mosaic disease, and this finding led to efforts to breed other resistant varieties. Variety tests and breeding experiments with different kinds of fruits and vegetables were continued. It was shown that coconut bud rot was caused by a species of *Phytophthora*, and that vanilla root disease was a *Fusarium* disease. Citrus scab was controlled by spraying with Bordeaux mixture combined with an oil emulsion. The cigarette beetle in factories and warehouses and in baled tobacco was successfully controlled by the use of liquid hydrocyanic acid. Studies on insect transmission of the mosaic disease of sugarcane were continued, as well as the relation of insects to the breaking down of grapefruit in transit and storage. The prices of citrus fruits as affected by temperature, humidity, ventilation, and other factors were investigated. Guernsey cattle were introduced in continuation of experiments in the grading up of a dairy herd at the station.

The reduced income of the Guam Station and damage to buildings and crops by a severe typhoon in 1923 caused a diminution of both experimental and extension work. Tests of forage plants were continued, including Napier grass, Guatemala grass, Japanese cane, alfalfas from South Africa, and adlay from the Philippines. Corn, cowpeas, and velvetbeans in rotation produced largely increased crops. Pigeonpeas and velvetbeans proved useful as cover crops. Pot experiments with old and new soils showed the need of lime. Experiments in the up-grading of native cattle, swine, goats, and poultry were continued. Copra meal was used successfully in feeding experiments with horses and cattle. Swine were fed, with good results, on a ration consisting of cooked breadfruit, damaged rice, copra meal, and tankage.

In the Virgin Islands the appointment of a new director of the station in 1922 brought about considerable reorganization of the work. The area devoted to experiments in agronomy was reduced, but variety tests and culture experiments were continued with sugarcane from various countries, sorghums, cowpeas, soybeans, hybrid corn, sweetpotatoes, Bermuda onions, and other vegetables. More attention was given to animal husbandry, and the up-grading of the station's dairy herd was undertaken.

BUREAU OF HOME ECONOMICS

Before it became the Bureau of Home Economics, July 1, 1923, the Office of Home Economics in the States Relations Service had continued experimental work during the fiscal years 1922 and 1923 along the general lines previously described (p. 232). Household methods of preparing pectin extracts from apples and from the peel of oranges and lemons were worked out, and these extracts used in making jellies and jellied preserves. Studies of the internal temperatures in foods during cooking were continued. Cooking tests were made with green-leaf vegetables and with hams, shoulders, and bacon cured by different methods. Investigations in pastry making were completed. The physical structure and condition of the fat was found to be more important than its chemical composition.

Digestion experiments on the starches of corn, wheat, rice, and potatoes were made with women as subjects. Respiration calorimeter studies on energy expenditure in household tasks, e. g., sewing by hand and by machines, and dish washing, were continued. Experiments were made on the care and repair of household equipment, especially floor coverings, china, and glassware. In cooperation with the Bureau of Agricultural Economics and the New York State College of Agriculture a survey of the standard of living in 400 farm homes in Livingston County, N. Y., was made.

When the Bureau of Home Economics took the place of the Office of Home Economics considerable time necessarily was spent on problems connected with the reorganization of the force, the new housing and equipment of the Bureau, and determination of its lines of work. Many data on which to base further studies were collected and preparation was made to revise earlier publications of the Office of Home Economics which needed to be brought up to date. The revision of Bulletin 28 of the Office of Experiment Stations, on The Chemical Composition of American Food Materials, was undertaken. During the first year the Bureau's organization included divisions of food and nutrition and of economic studies. In the second year a division of textiles and clothing was added.

Studies of methods of cooking vegetables were continued, as well as those on the internal temperatures of cooked foods, especially eggs. Soft-wheat flours were investigated and experiments made in bread making with such flours. Salted vegetables were studied with reference to their uses other than for pickles. Problems in home canning of fruits, vegetables, and meats were investigated, and covered the times and temperatures required for processing in glass containers and the cause of change of color in canned fruits. Information on the calculation and preparation of diabetic diets was collected. Studies of the vitamin content of foods and its variation under different conditions of production and handling were undertaken. Scales of relative food requirements, by age and sex, for calories, protein, and mineral constituents of the diet, were established. A short method for calculating the nutritive value of the diet was devised. The respiration-calorimeter laboratory was transferred to the Bureau of Animal Industry. The results of surveys on standards of living on farms in Alabama, Kentucky, New York, and Vermont were analyzed. The use of time by homemakers was studied. A summary and compilation of information to help the housewife in selecting fabrics was undertaken, beginning with cotton goods. Further study of home laundering was begun. A study of designs for children's clothing was begun, and included the relation of these designs to habit formation.

BUREAU OF AGRICULTURAL ECONOMICS

The Bureau of Agricultural Economics was formed July 1, 1922, by bringing together the Bureaus of Markets and Crop Estimates (which had been united July 1, 1921) and the Office of Farm Management and Farm Economics. The new bureau had a rapid development and by July 1, 1924, had 990 employees in its Washington offices and 148 branch offices in 79 cities, with 936 workers. It continued much of the work previously undertaken, added some new

projects and considered more broadly the problems requiring economic research. Among the activities given special attention from the first were marketing-cost studies; the collection of information on agricultural competition of foreign countries with the United States and the demand for American farm products in foreign countries, and the effecting of arrangements for securing information as to condition and production of crops in various foreign countries; an analysis of the economic situation in the livestock industry and the development of plans leading to the more orderly marketing of livestock; a study of fruit-auction companies; the expansion of the work of collecting statistics of livestock production; the formulation and perfecting of grades and standards for farm products; the inauguration of a shipping-point inspection on fruits and vegetables; the development of the radio news service; the inauguration of a grain news service; and the carrying out of the greatly increased activities under the United States Warehouse Act.

Incessant demands for aid grew out of the agricultural depression, which reached a critical stage between 1921 and 1925, and led to great expansion of previously more or less limited surveys relating to various agricultural industries, and of the service and informational work of the Bureau. Much of the Bureau's activity was devoted to studies on the formulation of standards for grading and classifying various agricultural products and to revising the original standards according to experience in their use. Mandatory or permissive standards were worked out for 32 kinds of fruits and vegetables, for wheat, corn, oats, rye, rice, barley, grain sorghums, flax, hay (from timothy, clover, alfalfa, or mixed grasses), cotton, wool, tobacco, butter, eggs, and a number of classes of livestock and dressed meats.

Studies of different types of farming and their distribution in the United States were continued. Examples of such studies were those on the development and requirements of agriculture in the northern Great Plains; irrigated farming in Idaho and Washington; cattle production in Illinois, Iowa, and southwest Virginia; sheep raising in Minnesota and North Dakota; range cattle in Colorado and Texas; ranch organization and farm practice in Montana, North Dakota, South Dakota, and Wyoming; dairy production in New York, Pennsylvania, Vermont, Virginia, and Wisconsin; and on poultry farming in the Pacific Northwest. In these and other studies much attention was given to collecting and interpreting data on costs of production of cereals, potatoes, cotton, tobacco, fruits, livestock, dairy and poultry products, and others.

Large numbers of farm accounts and other business records from different parts of the country were collected and analyzed with reference to the returns on farm capital, labor income of the farmer and his family, and the margin between annual receipts and expenses. Studies were made in areas around a number of cities to determine to what extent the farmers there were meeting the needs of local markets.

Many marketing investigations were conducted through divisions of the Bureau giving special attention to grain, hay, feed and seed, cotton, fruits and vegetables, and livestock, meats, and wool. Since the merchandizing of grain had become highly specialized and

technical, the Bureau undertook to investigate matters underlying the problems presented. Studies were made of the content and quality of gluten in wheat, the milling and baking qualities of different varieties, and the value of wheat in varying conditions of damage caused by heat fermentation, by smut, and by admixtures of weed seeds. Studies of the color of hay as an index to its feeding value and price resulted in the devising of a machine for measuring the color.

Cotton-marketing investigations included studies of (1) the underlying economic laws operative in growing the crop and in its marketing and consumption at home and abroad, (2) methods and practices in primary markets, and (3) the statistical relationship between the various factors controlling supply, demand, and price. Spinning tests of new varieties and of Pima and Acala varieties used in the Southwest were made. Laboratory tests were made of individual fibers, strength of yarn, and percentage of moisture in cotton at different stages of manufacture. The organization and operation of auction companies marketing fruit and vegetables were studied. The distribution of citrus fruits from California and Florida was analyzed. Records of shipments were compiled by commodities and by States.

Livestock-marketing studies were made with beef cattle in Virginia and in five of the Corn Belt States. A Nation-wide investigation of methods and practices in retailing meats was made. Methods and practices of wool marketing were studied.

The marketing of dairy products was investigated, special studies being made in New England, New York, and Oklahoma. Poultry and egg marketing were studied in Europe and through surveys in Georgia, Illinois, and North Carolina.

The organization and operation of cooperative organizations dealing with agricultural products were studied throughout this country and in Europe, especially in Denmark and Russia. Studies of the history, economics, and legal aspects of cooperation, and of the relation between cooperative and private marketing, were made. Among the studies of associations dealing with particular products were those on milk marketing, farmer-controlled creameries, grain elevators, maple-sap products, tobacco marketing, cotton gins, and the California Fruit Growers' Exchange.

In the field of land economics there were studies on the trend of land utilization, the course of food consumption since 1839, the future needs for land for agriculture, the Federal and State reclamation policies, the cost of establishing farms on reclamation projects, the incomes from irrigated farms, the relation of land income and appraisals to land values, land ownership and tenancy.

Studies in agricultural finance dealt with problems of farm taxation and short-term bank credit. Statistical and historical surveys of the agriculture of Denmark, France, Germany, Poland, Switzerland, Argentina, Chile, and Peru were made. Bases for forecasting prices through statistical analyses were developed.

Among rural-life studies were those relating to the make-up and movements of farm population, standards of living on the farm, living conditions of farm tenants, social aspects of farm tenancy, functions of farmers' trade and service centers, and rural social organizations.

AGRICULTURAL EXPERIMENT STATIONS, 1921–25

The widespread agricultural depression which occurred during this period made the farmers more than ever desirous of getting such help as they could from the experiment stations, which in larger measure they recognized as sources of new knowledge for their benefit. Often their appeals were, in the first instance, made to the extension agents with whom they were in close touch. This situation made the extension workers increasingly eager to get helpful information from the stations and therefore more active in promoting the further development of the research work of the stations. The authorities of the land-grant institutions with which the stations were connected began to take increased interest in promoting agricultural research, the need of which was impressed upon them from various sources.

A decline in the number of agricultural students, caused by the discontent of farmers with the economic condition of agriculture, as well as their lack of funds for the higher education of their children and the necessity in many cases of keeping the young people at home to work on the farms, was reflected in a decrease of the teaching loads of station workers, about one-half of whom had part-time duties as instructors. The way was thus opened for them to give more attention to their researches. Changes in the post-war status of some industries with which former station officers had been connected brought a considerable number of them back to the stations. The increased number of students taking graduate courses in subjects related to agriculture made more young persons available as well-trained assistants or, in some cases, as leaders of station projects. There were more graduate students who were capable of helping in research projects during their graduate study.

A moderate increase in the salary scale for scientific and technical workers at the stations also helped to retain or procure efficient research members of the station staffs. In 1925 the salaries of department heads, project leaders, and independent workers ranged from $2,400 to $6,000. In most States they were from $3,000 to $4,500, but in nine States $5,000 or over, and in only three States from 2,400 to $2,750.

In the land-grant institutions a clearer distinction was made between research, regulatory, extension, and service work. The regulatory work in the States was increasingly taken over by the State departments of agriculture. The more thorough organization of the extension work, which carried with it more or less service work, made the relations of the stations to these lines of work more satisfactory, though a considerable number of station workers continued to give more or less of their time to such duties. On the whole, therefore, the condition of the stations improved steadily though slowly during this period.

The number of administrative and technical workers in the stations continued to grow, and in 1925 there were 2,415, of whom 1,265 also engaged in teaching and 347 in extension work. About 1,200 were project leaders. More of the investigators had received advanced degrees.

For various reasons, largely growing out of the departmental organization of the land-grant institutions, station directors in only

20 States gave their full time to station administration; in 18 States the directors were also deans of the agricultural colleges; in 3 States one person was director of both the station and the extension service, and in 7 States the offices of dean and director of the station and of extension service were combined. In some States an assistant or vice director of the station was employed.

The total income of the stations for the year beginning July 1, 1921, was $7,660,570 and for the year ended June 30, 1925, it was $10,343,695. The annual Federal appropriations under the Hatch and Adams Acts remained at $1,440,000. The State appropriations grew to $5,827,871, an increase of something over $2,000,000; the inspection fees became $427,486, an increase of less than $70,000; and the receipts from sales of farm products in 1925 amounted to $1,390,480, an increase of a little more than $220,000. But, for reasons previously stated the amount annually available for administration and research did not greatly exceed the sum of the Federal and State appropriations. By 1925 all the States were making contributions to the stations. The amounts differed greatly in the several States. That year the stations in California, Illinois, Minnesota, and Ohio received over $300,000 each, 7 stations had from $217,000 to $285,000, 11 from $100,000 to $156,000, 10 from $60,000 to $97,000, 8 from $25,000 to $47,000, 4 from $12,500 to $17,500, and 5 less than $10,000. The North Dakota Station had a balance of $178,366 carried over from the previous year. The amount annually spent during this period for additions to the station equipment averaged about $1,425,000, including about $850,000 spent for buildings. In addition, a number of large buildings were erected for the joint use of the agricultural colleges and experiment stations.

The number of station projects continued to increase. In 1925 there were 5,538 in the 48 States, in addition to 150 in Alaska, Guam, Hawaii, Puerto Rico, and the Virgin Islands. The number of projects in rural economics more than doubled between 1921 and 1925 and became 201, in addition to 34 in the field of rural sociology. The latter included studies in social organizations, relation of towns and villages to the open country, standards of living, rural religious organizations, and problems relating to the schools. About 130 projects at 33 stations dealt with subjects in home economics. The number of projects in the other principal lines of work was as follows: Field crops 1,817, horticulture 952, animal production 926 (including dairy cattle 191 and poultry 205), plant pathology 482, entomology 472, soils 343, fertilizers 213, veterinary medicine 203, agricultural engineering 189, botany 144, genetics 126, dairy products 106, forestry 100, and foods and human nutrition 54. There were also 54 administrative, regulatory, and miscellaneous projects.

The number of projects was still larger than could be adequately financed with the available funds. There was, however, a praiseworthy tendency to define the individual projects more strictly. The amount of intensive and highly specialized research had materially increased. Examples of such work were the studies in genetics carried on with small animals; on vitamins; on the composition and qualities of proteins; on the life history of groups of insects and of fungi; and on particular diseases of plants and animals. There was a larger use of lysimeters in soil studies, of the complicated

apparatus for maintaining temperatures in soils and air, and of apparatus for studies of nutrition of animals, and special buildings were designed and used for research in sugar making, cheese manufacture, grain milling, and in handling fruit and fruit products.

Field experiments and observations were more frequently reinforced by laboratory studies. Regional problems were sometimes studied by a number of stations separately but often in cooperation with each other or with the United States Department of Agriculture. The increase in specialization was doing away with unnecessary duplication of research but was also making it more sure that results would be properly tested and that complicated problems would be attacked from different points of view. While immediately pressing problems were not neglected, there was more planning of long-time investigations with a view to securing results of fundamental importance.

PASSAGE OF THE PURNELL ACT

The growing interest in the economic and social problems of agriculture and country life, intensified by participation of the United States in the World War, led officers of the agricultural colleges and experiment stations to seek increased funds which might be used for research in these lines. During 1918 President K. L. Butterfield and A. E. Cance, of the Massachusetts Agricultural College, and C. G. Woodbury, of the Indiana Experiment Station, corresponded with other agricultural leaders with reference to an effort to secure an appropriation for research, particularly in agricultural economics, rural life, and farm management. The results of this correspondence were reported to the executive committee of the Association of American Agricultural Colleges and Experiment Stations, who presented them to the meeting of that association at Baltimore, Md., January 8–10, 1919. The history of this and other events leading up to the passage of the Purnell Act was given by J. L. Hills, of the University of Vermont, and E. W. Allen, of the Office of Experiment Stations, in a paper read before the Association of Land-Grant Colleges and published in its proceedings for 1925 (*88*). The following statements are based on that paper.

At the Baltimore meeting in January 1919 the committees on college organization and policy and on experiment station organization and policy stressed the need of research along economic and sociological lines. The whole matter was then left to the discretion of the executive committee. It was brought up again at the meeting of the association at Chicago, Ill., November 14–19, 1919, when the station committee suggested the need of a new measure for Federal aid to the stations. This led to an appeal for increased research funds by the executive committee at a hearing before the House Committee on Agriculture.

Under the leadership of E. A. Burnett, dean of the College of Agriculture of the University of Nebraska, R. L. Watts, dean of the School of Agriculture of Pennsylvania State College, and C. G. Woodbury, former director of the Indiana Experiment Station, an informal conference was held at Chicago, April 22, 1920, at which an amendment to the Hatch Act, providing for additional Federal appropriations with corresponding State offset to be spent mainly

for research in agricultural economics, rural sociology, and home economics, was advocated. This proposal was presented to the executive body of the association at Springfield, Mass., October 19–22, 1920, and was discussed at length. The executive body finally voted in favor of a definite effort to secure from Congress for the experiment stations additional Federal funds gradually increasing in amount but without State offset, the funds to be applied to research in agricultural economics and sociology and home economics, but also to research in agricultural production.

A bill for this purpose was then drafted by F. B. Mumford, dean of the Missouri College of Agriculture, and this bill, with some changes, including the addition of a provision for printing and distribution, was by the advice of the executive committee sent to G. I. Christie, director of the Indiana Experiment Station, who secured the consent of Fred S. Purnell, a Member of the House of Representatives from Indiana, to introduce the bill in Congress. This was done January 17, 1921, and again in the next Congress, April 11, 1921; but it did not get beyond the Committee on Agriculture, to which it was referred. The language of this bill was the same as that of the Purnell Act, as finally passed, except that it provided for an initial appropriation of $15,000, to be increased $10,000 annually until a maximum of $85,000 was reached, these amounts being the same as those proposed at the Chicago conference in 1920. This bill was much in evidence in the proceedings of the Association of Land-Grant Colleges from 1921 to 1924, and active efforts were made to secure its passage. Hearings at which statements were made by members of the association were held before the House Committee on Agriculture on January 26 and February 23 to 25, 1922. The active support of influential organizations was secured, including that of the American Farm Bureau Federation, national, State, and local granges, and the American Bankers' Association.

Congressman Purnell for the third time introduced his bill in the Sixty-eighth Congress, December 5, 1923 (H. R. 157). A duplicate bill (S. 137) was introduced in the Senate December 6, 1923, by E. F. Ladd, Senator from North Dakota, former president of the agricultural college in that State. Friends of home-economics research made an effort to have that subject definitely provided for in the bill, but it was finally decided that this was not expedient.

The bill was reported back to the House from the Committee on Agriculture on May 15, 1924, with amendments which reduced the initial appropriation for each station to $10,000, with annual increments of $5,000 until a maximum of $30,000 was reached. In January 1925 the executive committee of the Association of Land-Grant Colleges explained to the President's Agricultural Conference, then in session at Washington, the difficult situation of the experiment stations with reference to research, with the result that the conference reported in favor of the passage of the Purnell bill in a statement said to have been written by R. W. Thatcher, then director of the New York State Experiment Station. The conference, however, suggested that the amounts of the appropriations be increased to $20,000 for the fiscal year ended June 30, 1926, with $30,000, $40,000, $50,000, and $60,000 for the next 4 years, respectively, and a maximum of $60,000 annually thereafter. These amounts were incorporated in the bill

which passed the House February 10, 1925. Senator Ladd withdrew his bill, thus permitting the passage of the Purnell bill in the Senate February 19, 1925. It was signed by President Coolidge February 24, 1925.

The act specified that this money be used for paying—

> the necessary expenses of conducting investigations or making experiments bearing directly on the production, manufacture, preparation, use, distribution, and marketing of agricultural products and including such scientific researches as have for their purpose the establishment and maintenance of a permanent and efficient agricultural industry, and such economic and sociological investigations as have for their purpose the development and improvement of the rural home and rural life.

The new appropriations were applicable to the stations already established under the Hatch Act, and, like those under that act and the Adams Act, were not to be dependent on equivalent contributions from the States. The act extended the same supervision by the Secretary of Agriculture that existed over previous appropriations for the stations. It therefore involved no new policy or administrative machinery, and no change on the part of the stations except an expansion of their activities.

A conference of representatives of the Association of Land-Grant Colleges was held at St. Louis, Mo., April 22, 1925 (*5*) "to consider policies and plans under [this act], and to bring into closer coordination and unity the investigations of the stations and the department." Secretary Jardine, in an address at this conference, urged that superficial investigation should be avoided and that "problems of fundamental importance should be attacked by adequate methods and with full knowledge of other investigations in order to avoid wasteful duplication."

It was held that this act did not relieve the States from their obligations to support agricultural research but rather that they should be stimulated to further extend their efforts in this direction. It was expected that the act would "lead to a considerable enlargement of the cooperative relations between stations, and with the various bureaus of the department," especially in the new fields of agricultural economics, rural sociology, and home economics. Six major topics, considered to be of national importance, around which to organize cooperation, were chosen and committees of specialists set up to formulate plans and procedure under each. They were (1) marketing and distribution of farm products; (2) the problem of surpluses; (3) vitamin content of food; (4) rural home management studies; (5) rural social organization and agencies essential to a permanent and effective agriculture; and (6) the factors which influence the quality and palatability of meat.

On May 20, 1925, Secretary Jardine issued a circular to the directors of the stations, pointing out that in view of the language of the Purnell Act, it was expected that expenditures from the Purnell fund would be limited to those incurred primarily for specific investigations, with such charges for publication and for special buildings and lands as pertain directly thereto, but need not be wholly restricted to new projects. The money might be used also on existing projects which it was desired to strengthen.

It was stated that the project system and the methods of accounting and reporting used in the administration of the Adams Act would

be followed. The Office of Experiment Stations was designated to represent the Department in matters relating to the details of administration of the law, and to aid in the promotion of activities under this act in the same general way as it had done theretofore in relation to the Hatch and Adams Acts.

All the States promptly assented to the provision of the Purnell Act, and the stations immediately began to formulate programs and budgets for the first year's appropriation. At the meeting of the Association of Land-Grant Colleges, November 17–19, 1925, the experiment station section and the executive body responded to the Department in a statement of policy which contained the following paragraphs:

> The Purnell Act is designed to promote sound investigation in accordance with modern conceptions of that term and the present status of knowledge. Progress at this stage calls for clear-cut, concrete proposals. This implies analysis of complex problems and the study of individual features by the most adequate means that research has disclosed, with the constant aim of strengthening methods and making inquiry more penetrating.
>
> Only a relatively small field in the several branches of a station can be covered at a given time. Hence the plan of concentrating on a few topics in each field and making the work comprehensive, thorough, and conclusive is highly important (*168, p. 183*).

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